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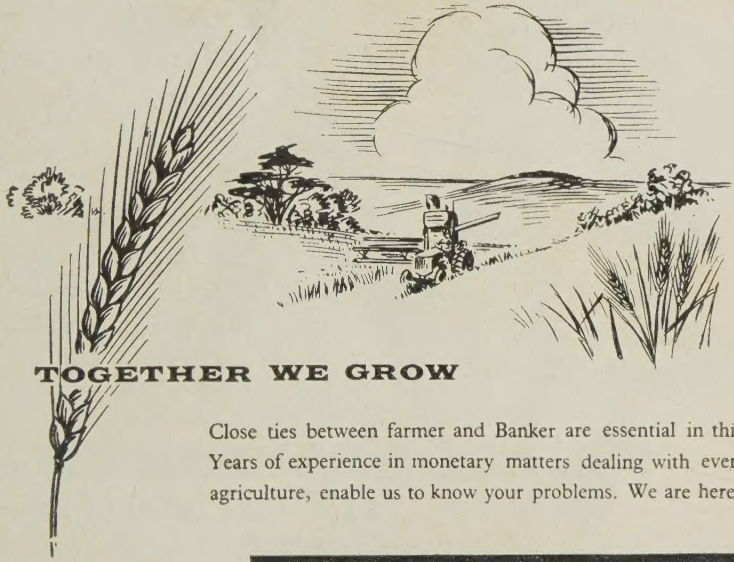

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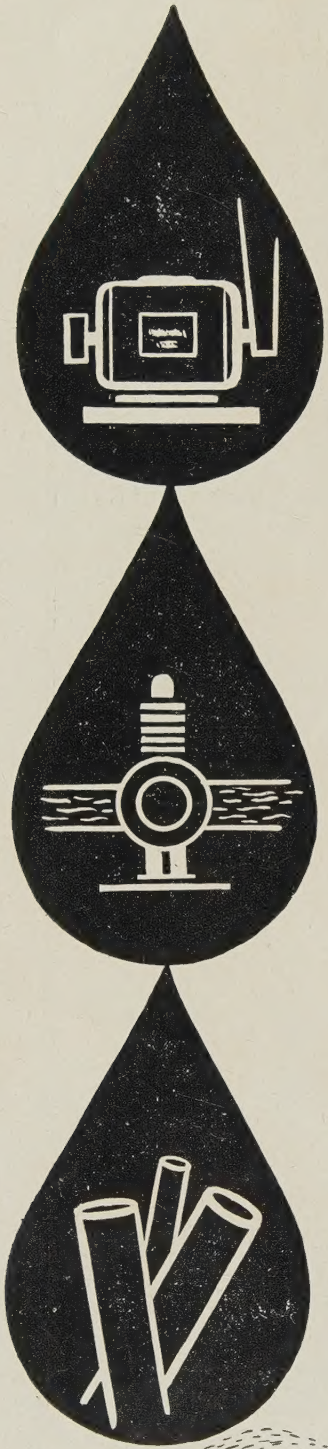

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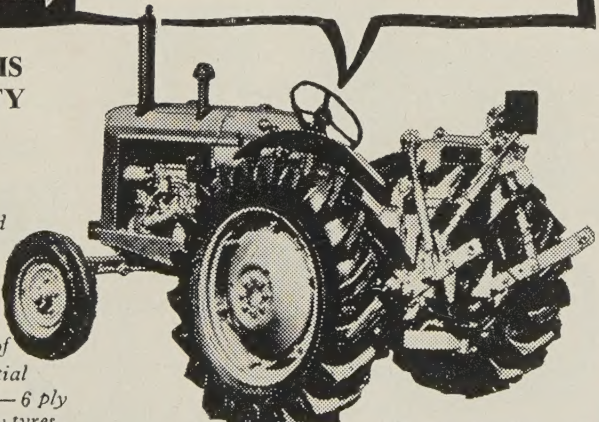

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CONTENTS

	PAGE
The Culture of Tilapia Nigra (Günther) in Ponds. IV—The Seasonal Growth of Male *T. Nigra* (*V. D. van Someren and P. J. Whitehead*)	79
Root-knot Nematode Surveys of Cultivated Areas in East Africa (*A. G. Whitehead and L. Kariuki*)	87
Field Immobilization of some East African Wild Animals and Cattle—I (*Lee Merriam Talbot*)	92
Effect of Management on Increasing Crop Yields in the Lake Province of Tanganyika (*J. E. Peat and K. J. Brown*)	103
A Statistical Design for a Pig Feeding Trial	109
The Culture of Carp (*Cyprinus Carpio* L.) in Ponds in Uganda. I—Preliminary Observations on Growth and Reproduction (*A. G. Wurtz*)	111
A Table of Estimates of Nutritive Values of Ruminant Feeds (*J. Glover, D. W. Duthie and H. W. Dougall*)	117
Average Nutritive Values of Kenya Feeding Stuffs for Ruminants (*H. W. Dougall*)	119
Insect Pests in the Coast Province of Kenya. I—Mango (*P. E. Wheatley*)	129
A Molasses Grass Variety Trial (*A. V. Bogdan*)	132
The Application of Research Results to Animal Health and Disease Control (*Sir Thomas Dalling*)	134
Release of New Cereal Varieties—1960 (*H. C. Thorpe and G. E. Dixon*)	139
The Estimation of Ankole and Zebu Cattle Weights by Girth and Measurement (*D. D. Thornton*)	140
Armillaria Mellea in Kenya Forests (*I. A. S. Gibson and N. A. Goodchild*)	142
Reviews	82, 91, 102, 108, 110, 116, 118, 133, 144

INDEX TO ADVERTISERS

	PAGE
Barclays Group of Banks	I
British East Africa Corporation	COVER PAGE 2
Dunlop Tyres	COVER PAGE 4
East African Breweries Ltd.	III
Gailey & Roberts Ltd.	VII, IX, X
Imperial Chemical Industries Ltd.	VIII
May & Baker Ltd.	COVER PAGE 3
National & Grindlays Bank Ltd.	V
Ndurumo Ltd.	IV
Shell Chemical Co. of Africa Ltd.	VI
Standard Bank of South Africa Ltd.	I
Wigglesworth & Co. Ltd.	II

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EAST AFRICAN AGRICULTURAL AND FORESTRY JOURNAL

THE CULTURE OF TILAPIA NIGRA (Günther) IN PONDS

IV—THE SEASONAL GROWTH OF MALE T. NIGRA

By **V. D. van Someren** and **P. J. Whitehead**, Fish Division (Research), Ministry of Forest Development, Game and Fisheries, Kenya Colony

(*Received for publication on 3rd February, 1960*)

Part II of this series of papers described the layout of a first series of experiments on the basic growth of male *T. nigra* in monosex culture, carried out at the Inland Fishery Research Station of this Ministry at Sagana. It dealt with variability in size at the end of six months' growth in each pond, which could be attributed to the variations in pond conditions themselves, notably as regards depth and turbidity. The detailed growth from month to month of these fish was not analysed, but references were made in both Part II and Part III of this series to the fact of seasonal variability in growth of any one batch of fish which had been studied.

This present paper now deals with a more detailed analysis of this seasonal variability, which has now been followed for over 16 months, at monthly intervals, for one of the stockings used in this first series of experiments. The pond under review is that labelled A6 in Part II. This is a half-acre pond, run at an average depth of 2 ft., and somewhat turbid; it was stocked originally with 100 fish of which 25 were tagged, and 75 untagged. The environmental characteristics of this pond have already been described.

METHODS

The pond has been seined with a $\frac{1}{2}$ in. mesh net at intervals of one month since the first stocking in July, 1958, the number of days between each seining being kept similar as far as circumstances would permit. All the fish, both tagged and untagged, caught in one seine haul have been measured on the flat to the nearest millimetre, and their bulk weight measured to the nearest 0.1 lb. The fish have then been returned alive to the pond each time. To the time of writing (January, 1960) the fish have been examined 18 times, but the present results deal with only the first 15 months' growth. The original sexing of these fish was done by examination of external genitalia, and has proved completely accurate, no females or fry having ever been found in the pond.

It is possible that such once monthly netting does in some way affect the growth of the fish, but whether adversely or not, is not known, since some regular disturbance of the pond bottom may in fact enhance fertility. On each occasion the fish were removed from the pond for not more than 15 minutes.

Continuous water temperatures have not been recorded in A6 but in an adjacent pond, A3; since both ponds are deep and turbid, there is no reason to suppose their temperature régimes have been different. Environmental data such as air-shade temperature are recorded twice daily in a nearby Stevenson screen; sunshine is recorded continuously (Campbell-stokes recorder); wind speed (m.p.h. anemometer) and evaporation (standard pan) once daily; rainfall once daily, and pond water conductivity and transmission density once weekly. In Fig. 2 all these environmental variables are graphed, not on a calendar month basis but as an average per day from the actual date of one fish measurement to the next, thus indicating averages actually occurring during the growth interval measured. These periods varied from 26 to 32 days.

STOCKING DENSITY OF FISH

The growth and size at any time of *T. nigra*, as with most other fish, is known to be very precisely related to the stocking density of the fish, and the increasing biomass as the fish grow. Any variation of stocking density during the course of observations, therefore, caused by any unusual mortality at any time, will affect the growth rate by tending to accelerate it temporarily; deceleration of growth could be caused by an increase in biomass, due for example to breeding. Breeding has not occurred in this pond, hence decelerations of growth observed periodically are caused by changes in the pond environment.

Total population estimations each month would only be possible by total drainage, which is undesirable in experiments of this nature, since subsequent refillings markedly alter the pond water composition. It was therefore hoped to obtain some estimate of mortality by the differential recapture of tagged and untagged fish monthly; this naturally depends on a reasonably constant netting efficiency both as regards the net used and the labour using it. In the fifteenth month of observation the pond was seined five times until it was certain that all fish had been recovered, and a total count made.

This final estimation showed that only 69 of the original 100 fish remained at that time, a survival percentage which has been found in other experiments (*see* Part II). Therefore, there had been a loss of some 30 per cent of the stocked fish at some time during the course of the experiment, though it is not easy to deduce from the figures when these losses occurred. Unfortunately it was not possible to use the same netting gang each month, and this at once introduces variation in the efficiency figures, since it requires only one man carelessly to lift the foot-rope too soon and cause a high percentage of recording loss in such a small population. The same net had, however, been used each time, and there is no reason to suppose its efficiency had varied.

The last column at the top of Fig. 1 shows that when the total population remaining was estimated, the first net haul had caught some 80 per cent of the fish known to be present at that time. From July, 1958, to March, 1959, when approximately the same netting gang had been employed, the percentage net recoveries in one haul averaged 60 per cent, and remained remarkably steady (calculated on 100 fish stocked). It seems likely this figure is too low, and should be corrected by some 20 per cent, which seems to indicate that perhaps 20 per cent of the mortality occurred within the first month after stocking. Since the fish were stocked at an average size of 7-9 cm., and subsequent experiments have indicated that sizes below 10 cm. are in fact liable to mortality after handling for sexing, it also seems likely that the population remained stable at 75-80 per cent fish stocked after the first month for the first eight months.

From April, 1959, onwards, it became necessary to change the netting gang completely, and efficiency dropped immediately, the lower percentages of fish netted each month being clearly indicated in Fig. 1 for about four months; thereafter efficiency again increased as they became trained. Such frequent nettings tend to detach tags from fish; it is nevertheless still possible to distinguish a fish which has lost its tag by the scar remaining at the base of the dorsal fin. From March onwards, therefore, the percentage recoveries of tagged fish have been corrected monthly for the decrease in numbers of fish actually bearing tags. It is apparent from the total estimation figures, however, in the fifteenth month that there had been, during the eleventh to fifteenth month, a proportionately higher mortality of tagged fish, only seven fish bearing tags being recovered out of the original 25 stocked. Adding to these the six fish known to have lost tags, this gives a total survival of tagged fish of 52 per cent. Sixty-two fish without tags were recovered; deducting from this total the six fish now without tags, which had been marked previously, this gives 56 untagged fish surviving out of an original 75, or a survival rate of 74.5 per cent. There had therefore been a differential mortality. In the March, 1959, seining, 13 tagged fish had been recovered in one haul; thereafter the highest number ever recorded was seven in one haul (in September, plus two lost tags). It therefore appears probable that this higher mortality of tagged fish had occurred some time in the last six months of observations. There has therefore been a decrease in total fish numbers in perhaps two stages—a 20 per cent loss after the first month, rising to 30 per cent after the eighth month.

GROWTH OF FISH PER MONTH

The detailed monthly growth of fish is shown in two ways in Fig. 1. Firstly, as a general growth curve for both tagged and untagged fish, and secondly as a block increment per month for tagged and untagged fish. It will be noted that apparently the tagged fish show slightly less growth per month than the untagged fish, the latter curve rising more steeply up to the fifth month after stocking, until the average size of both groups is the same, and thereafter the untagged fish average slightly larger the whole time, with a difference of about 1 cm. After 19 cm., however, both growth curves are roughly parallel.

This is not an expression of the possibility that tagging depresses the growth of the fish. It is due to the fact that on average the tagged fish were almost 2 cm. larger on stocking than the untagged fish, a selection for size having been exercised at the time of marking in order

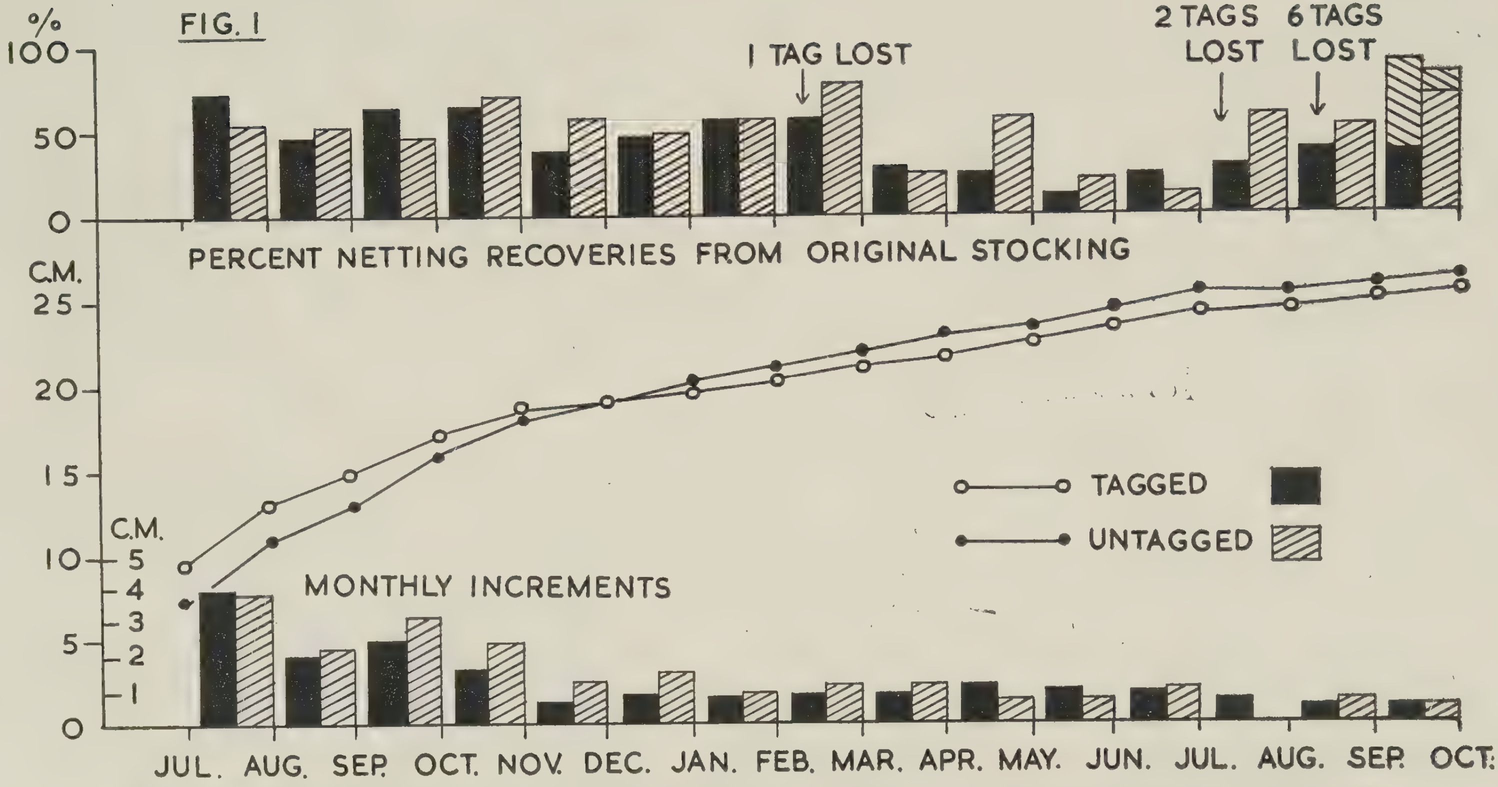

Fig. 1—Seasonal growth of male *T. nigra* in Pond A6. From March onwards, the per cent netting recoveries have been corrected for loss of tags as shown. The last two columns show the per cent of netting recoveries from the known surviving population in October, 1959. The known survivors at 15 months were 69 per cent of the original stocking, i.e. 138 fish per acre.

to facilitate the operation. The growth curve for *T. nigra* rises steeply for the first few weeks after liberation of the fry, and thereafter flattens out. Because of the skew shape of the curve, therefore, the tagged fish at time of stocking were already approaching the flatter portion of the curve, the untagged fish being at an earlier, steeper portion of it. The two batches were thus exploiting the reduced stocking conditions at different times in their original overstocked growth curve, and since increment potential decreases with size, the larger tagged fishes therefore appear to grow more slowly.

The shape of this curve is characteristic for fish in general. Although for *T. nigra* we have as yet no actual figures for growth in the first few weeks of life, the curve is steep for perhaps four to five months after birth at this low rate of stocking, becoming asymptotic to an asymptote of about 27-28 cm. in about 18 months at this rate of stocking in this size of pond. This is shown in the Ford-Walford plot of growth for untagged fish in this pond (Fig. 3). On this, the line of growth has been fitted by eye, and prolonged to an intersection with the bisector; but with the very slight differences in the last few months of observation it appears equally possible that the growth might in fact be arithmetic, and the latter part of the growth line is actually parallel to the bisector, as has been found for the perch by le Cren (1958).

SEASONAL GROWTH BY MONTHS

Figure 2 shows the monthly growth of these fish graphed against the environmental conditions prevailing between one set of observations and the next. The top portion shows monthly growth as a curve indicating increase or decrease in actual length increments per month for tagged and untagged fish. In a more striking fashion, the weight increases or decreases are shown for the untagged fish only, these being the weight increases or decreases which the increments in length actually represent at any given length. These have been calculated from the length/weight curve already determined for *T. nigra* males (Part III). Since length/weight relationship is logarithmic, at the larger sizes of fish it follows that a length increment of as little as 0.5 cm. may represent a weight increase of as much as a 3.0 cm. length increase in a much smaller fish.

AIR AND WATER TEMPERATURE

As shown in the lower part of Fig. 2, air-shade temperatures and water temperatures follow one another very closely. Although maxima do not differ a great deal and fluctuations of maxima and minima follow one another, there is a far greater diurnal range of air temperature than of water temperature, the water medium having greater heat retention powers. Thus water maxima and minima differ daily (or monthly) by seldom more than 5 deg. F. (approximately 3 deg. C.), whereas air temperatures may show a difference of as much as 15 deg. F. in similar periods.

From August, 1958, to May, 1959, there is a marked relationship between fluctuations of water temperature and the weight of fish. Thus the period November-December shows a drop in weight increase of some 6 gm., correlated with a fall in mean monthly temperature maximum of 2 deg. F., followed in December-January by a gain in weight increase of 5 gm. with a mean temperature increase of 1 deg. F. In the period January-February, a temperature drop of 4 deg. F. corresponds to a drop in weight increase of almost 15 gm. Thereafter weight increments are greater as water temperature rises to April, then again in April-May weight increase drops by 8 gm., with a fall in mean monthly temperature of 3 deg. F.

The close relationship between growth and temperature breaks down markedly in the period May-July, 1959, when weight increments increased in spite of falling water temperatures, and although one cannot be certain, it is suspected that this increasing weight was in fact due to the increased mortality of fish about this time already mentioned above; the decreased biomass of fish allowing higher weight increases of survivors in spite of lower temperatures until the total weight of all fish rebalanced itself with the pond potential. Thereafter, in July-August the relationship is renewed, there being no weight increase as water temperature reached its lowest mean for the year, followed again by a large increase in weight as water temperatures rose again in August-September. The effect of temperature on the growth of fish is well known (Brown, 1957), fish being affected both directly and indirectly.

OTHER WEATHER CONDITIONS

Water temperatures, which affect the fish directly as the medium with which they are in immediate contact, are of course themselves the result of interaction of many other environmental conditions such as sunshine, wind, evaporation, rainfall and so on. These other conditions are also graphed monthly in Fig. 2.

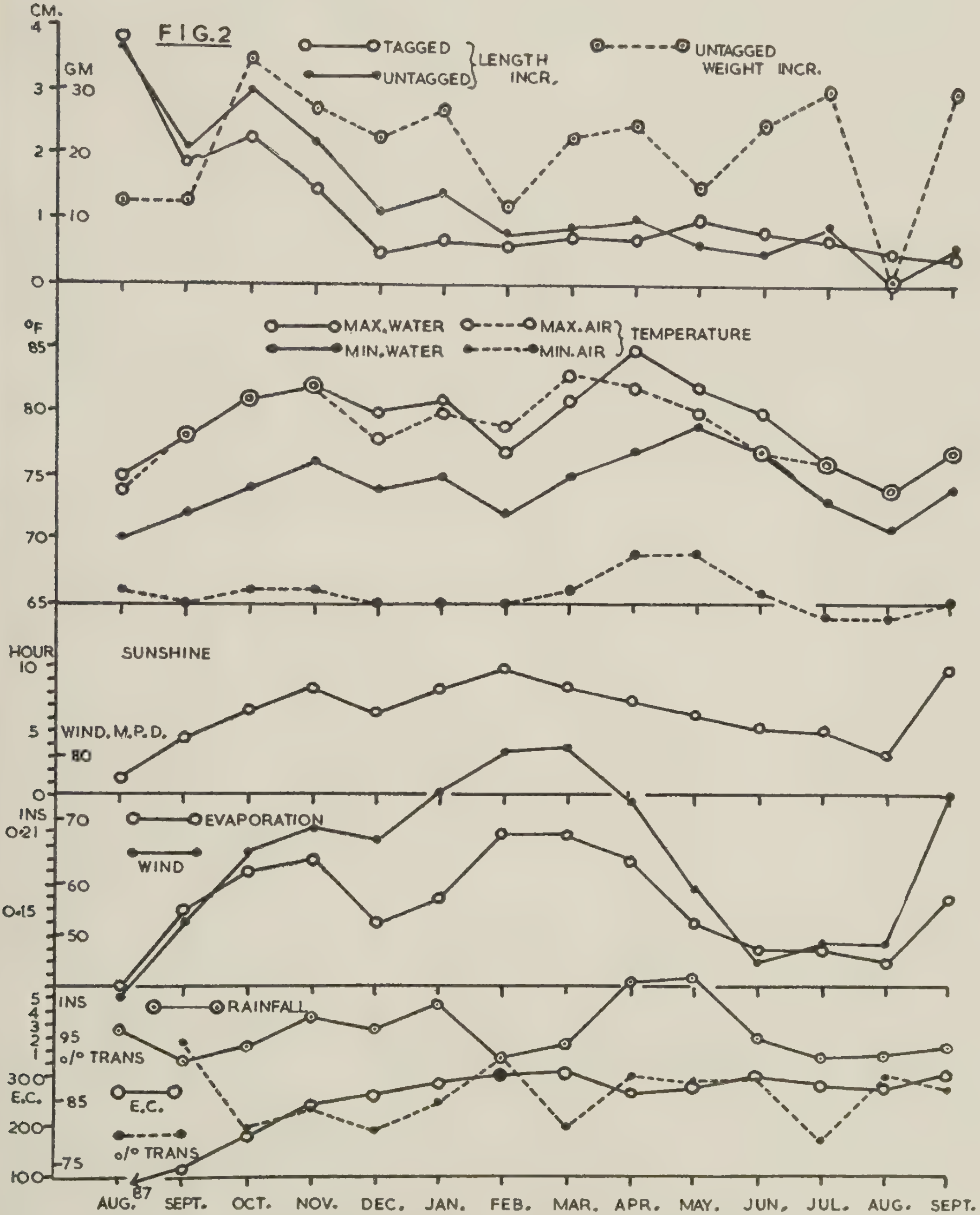

Fig. 2—The seasonal growth of male *T. nigra* in Pond A6. Monthly increments in weight and length of tagged and untagged fish shown against environmental data

The warming effect of increasing hours of sunshine on water temperatures is clearly shown up to January, 1959, but February is anomalous, when, in spite of 10 hours average daily sunshine, the water temperatures dropped, as did fish growth.

The period mid-December to mid-March is the short dry season in Kenya, when isolation and air temperatures tend to be maximal for the year, though the hotter days are offset by much cooler nights owing to radiation effects and clear night skies at this time. Coincidentally, greater sunshine, and greater warming of the land surface as a result, leads to a greater amount of thermals and consequently more wind. Higher winds and more sunshine together produce a greater evaporation rate for standing water, which in turn must lead to an actual cooling of the water body, and thus to an actual depression of fish growth. The potential effect of greater insolation on fish growth is thus apparently offset by the cooling effect of higher winds and higher evaporation.

The close relationship between sunshine, wind and evaporation throughout the year is clearly shown, and it is possible that their effect on warming or cooling water is subject to some time lag, as might be expected, and as is shown in the period February-April when water temperatures continued to rise in spite of decreasing insolation.

In general, the Sagana locality shows the twice yearly periodicity in rainfall characteristic of this eastern part of Kenya, the short rains falling in the period October-December, and the long rains in the period March-May, the rains being heavier in this latter season.

The actual months of rainfall vary from year to year somewhat, and in the year under observation, for example, the short rains were prolonged into mid-January. However, records for the last ten years at Sagana have shown that February, July and August are always months of minimal rainfall. February is always hot and sunny, with cold nights and high winds; July and August are dull and cloudy, with minimal winds and generally lower daily temperatures in the shade.

For the period August, 1958, to May, 1959, there is also a close resemblance between fish growth, water temperature and rainfall. The reason for any relationship between water temperature and rainfall is obscure, and though it may be fortuitious, there is perhaps some connexion in so far as that during periods of rain it is not necessary to keep the ponds topped up with water to the same extent as at other times. The pond water is drawn from the Ragati River by furrow, and is usually some 10 deg. F. lower in mean temperature than the pond water itself; if this is not used, there is not the same cooling effect as when such water is allowed in.

There is also the possibility, however, that rainfall on the ponds, and wash into them from the banks as a result of rain, may have a much more direct effect on fish growth by increasing the general pond fertility by addition of adventitious nutrient salts. This would require much more exact hydrologic and chemical analytic techniques than are at present possible; and similarly the amount of topping up required, and its possible effect on pond fertility, must also be considered in this connexion, though no analyses have yet been made.

The pond was first filled with Ragati River water in June, 1958, about three weeks before stocking. Ragati River water, which is analysed daily, shows an average conductivity of 40 reciprocal (r) megohms. As soon as this water becomes static in a pond, its conductivity rises, as electrolytes are dissolved from the pond bottom and pass into solution in the pond water. Conductivity of standing pond water at Sagana varies from pond to pond, depending on the type of soil in which the pond was made (Part III); and in this pond A6 it reached a maximum of 300 r/megohms in about six months. This figure has been held very steady on the whole, dropping only slightly in periods of dilution by heavy rainfall, as in April-May, 1959, as would be expected, and rising again as rainfall ceases. Daily fluctuations are greater or less, depending on the amount of topping up required, but in general the monthly averages of conductivity show no correlation with the observed fluctuations in fish growth.

The pond is somewhat turbid, and because it is held at 2 ft. water depth, both the degree of turbidity and the depth have not allowed the fish to reach their maximum growth rate (Part II). Nevertheless there appears to be no connexion on a monthly basis between turbidity and fish growth. Turbidity varies widely from month to month and bears no close relation to other factors, except perhaps date and number of hours of topping up, which is not recorded here; this operation always muddies the water when carried out.

FIG. 3

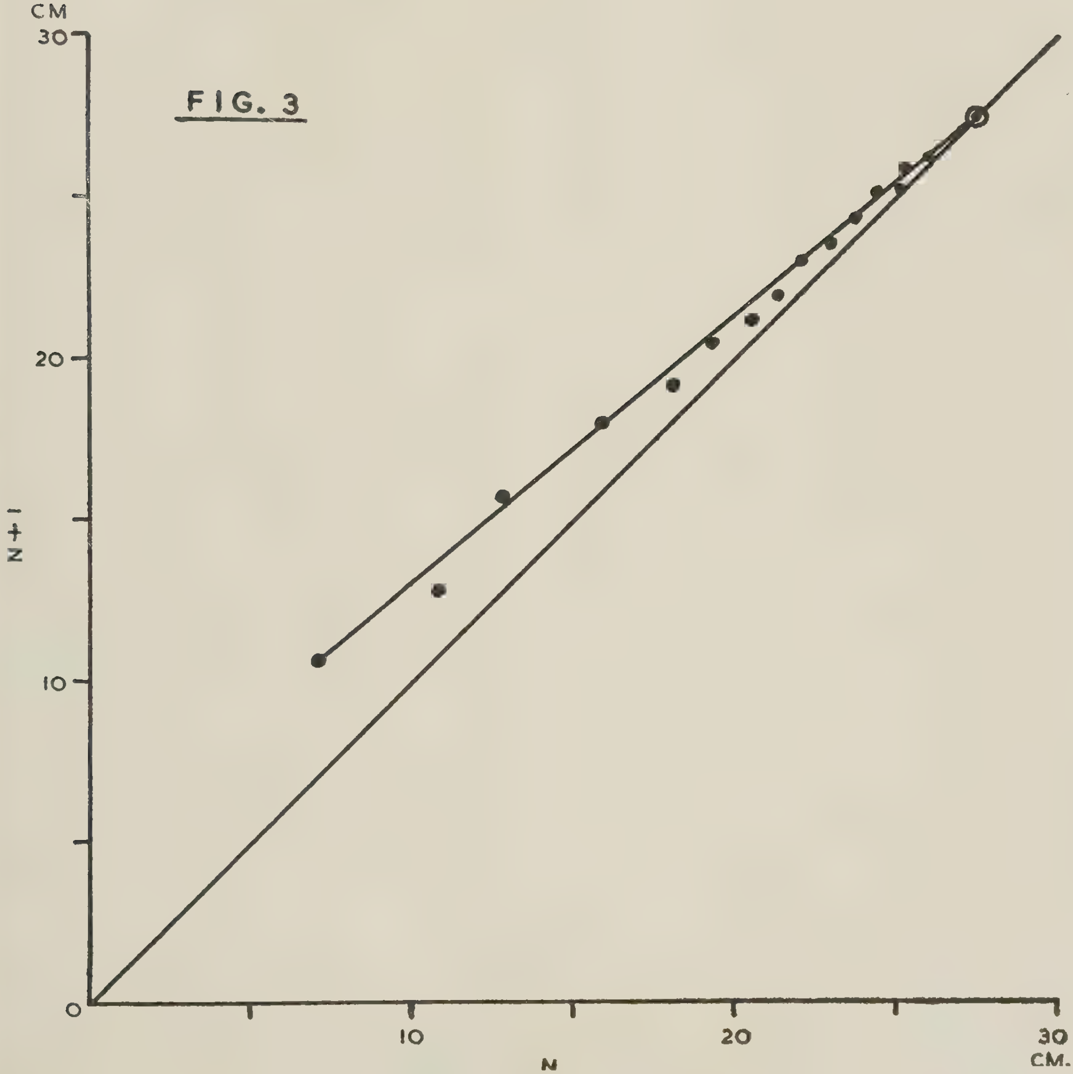

Fig. 3—Ford-Walford plot of growth of male *T. nigra* in Pond A6

DISCUSSION

It is clear from these results that once the initial growth burst has been achieved after stocking such small fish, their subsequent growth can be much affected by seasonal variation in water temperature, which is itself affected by other weather conditions, and also perhaps directly by rainfall. This seasonal variation is superimposed on the final size and weight attained at any given time, which is a function of biomass and pond size in relation presumably to food supply.

The relationship between length and weight of a fish is often expressed as its condition, being designated by the condition factor K. The results above have been expressed as a monthly variability in length and weight increments while maintaining a constant "ideal" condition factor of unity. This is seldom the case in practice, and K itself varies a good deal depending on conditions, and a fish of fixed length would vary in K from month to month depending on the environmental fluctuations, in addition to changes in its own internal state as regards growth of gonads and deposition of fat. Although they have not been calculated in this instance, it is very probable that monthly fluctuations of K would show almost exactly the same fluctuations as the weight increments graphed here for these isolated males; observation has in fact shown that in the months of July-August, for example, when these "ideal" weight increments are minimal, the fish are thinner, flabby, and in general in poor condition.

From these results, therefore, male *nigra* show two good growing periods, the best growth being achieved in the months September to January, and again in March to April; but that growth is minimal for a short time in February and again in July to August. It must be emphasized that this seasonal growth pattern is that occurring in the type of locality and environment such as that found at Sagana. Eleswhere, where environmental conditions are different, the seasonal growth pattern will be different.

SUMMARY

The growth rate of male *Tilapia nigra* is neither constant throughout life, nor from month to month. It decreases asymptotically in length as the fish grows older, and varies from month to month according to fluctuations in external environmental conditions, weight being more affected than length in the latter instance.

The most important external factor is undoubtedly the water temperature at which the fish live; rises and falls in mean temperatures of only a few degrees causing marked increases or decreases in weight achieved, respectively. Water temperature is in itself much affected by other weather conditions, and is not necessarily maximal in months of maximum sunshine owing to increased wind speeds and evaporation rate in such months. Rainfall may in itself also affect fish growth directly, though this is not fully established yet. In the environmental conditions present at Sagana, male *T. nigra* show two good growing periods and two poor growth periods every year.

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REVIEW

THE AGRICULTURAL REGISTER (New Series): Changes in the Economic Pattern, 1957-1959, published by the Agricultural Economics Research Institute, Oxford, 1960, 147 pp. Price 25*s*.

This book, with a somewhat misleading title, attempts to give a comprehensive picture of British agriculture, particularly in relation to Government policy. It gives the present position in regard to marketing of livestock, livestock products, crops, fruit and vegetables, and the economic relationships between agriculture and imports, labour, land and capital. It shows that economic progress in agriculture has been considerable, especially in regulated commodities.

The present issue contains completely new material bringing the position up to date. The book is of general interest,, in that while it deals exclusively with agriculture in the United Kingdom, younger countries have much to learn from the accumulation of economic experience.

ROOT-KNOT NEMATODE SURVEYS OF CULTIVATED AREAS IN EAST AFRICA

By A. G. Whitehead and L. Kariuki, East African Agriculture and Forestry Research Organization

(*Received for publication on 15th June, 1960*)

Several species of the plant-parasitic nematode genus *Meloidogyne* Goeldi ("root-knot" nematodes) are known to be widely distributed in East Africa, i.e. in Kenya, Uganda, Tanganyika and Zanzibar (Whitehead, unpublished data). Their presence in the roots of infested plants is generally associated with the production of "knots" or galls in the roots, within which the nematodes feed. Such galls, not to be confused with the bacterial nodules of legumes, or other gall-forming organisms, are known on the roots of almost every major and minor crop plant and on a large number of weed species in this region.

A series of intensive root-knot nematode surveys is being carried out over a wide range of climates and soils in East Africa, in order to obtain a clearer picture of the distributions of the several species, so enhancing their control by rotational measures.

MATERIALS AND METHODS

Surveys are being made of the root-knot nematode faunae of areas, each of approximately 50 square miles, selected from heavily cultivated regions, in differing East African macroclimates and soil types.

Samples of infested crop and weed species are collected from each village or sublocation, in each area selected. The identity of weed species is determined from pressed specimens and the roots of both crops and weeds processed for identification of the root-knot nematode species present.

Infested roots are washed free of soil and incubated at room temperature in closed jars containing a little water for 48 hours. An eye estimate of the degree of galling of the roots by *Meloidogyne* spp. can then be made, while the males and larvae emerging from the roots, and which collect in the water at the bottom of the jar, may be removed for subsequent study. The roots are then stained for two minutes in a boiling 0.1 per cent solution of cotton blue dye in lactophenol (Franklin and Goodey, 1949). After cooling to room temperature the roots are removed from the solution and cleared in lactophenol. The egg-laying females are then easily seen within the root galls and may be dissected out with mounted needles. The posterior end of the body of each female is cut off with an oculist's scalpel, and the body cuticle, bearing anus, tail end and vulva cut out and cleaned of body tissues. This is mounted in pure glycerine on a microscope slide, surmounted by a cover slip ringed with Thorne's cement (Thorne, 1935).

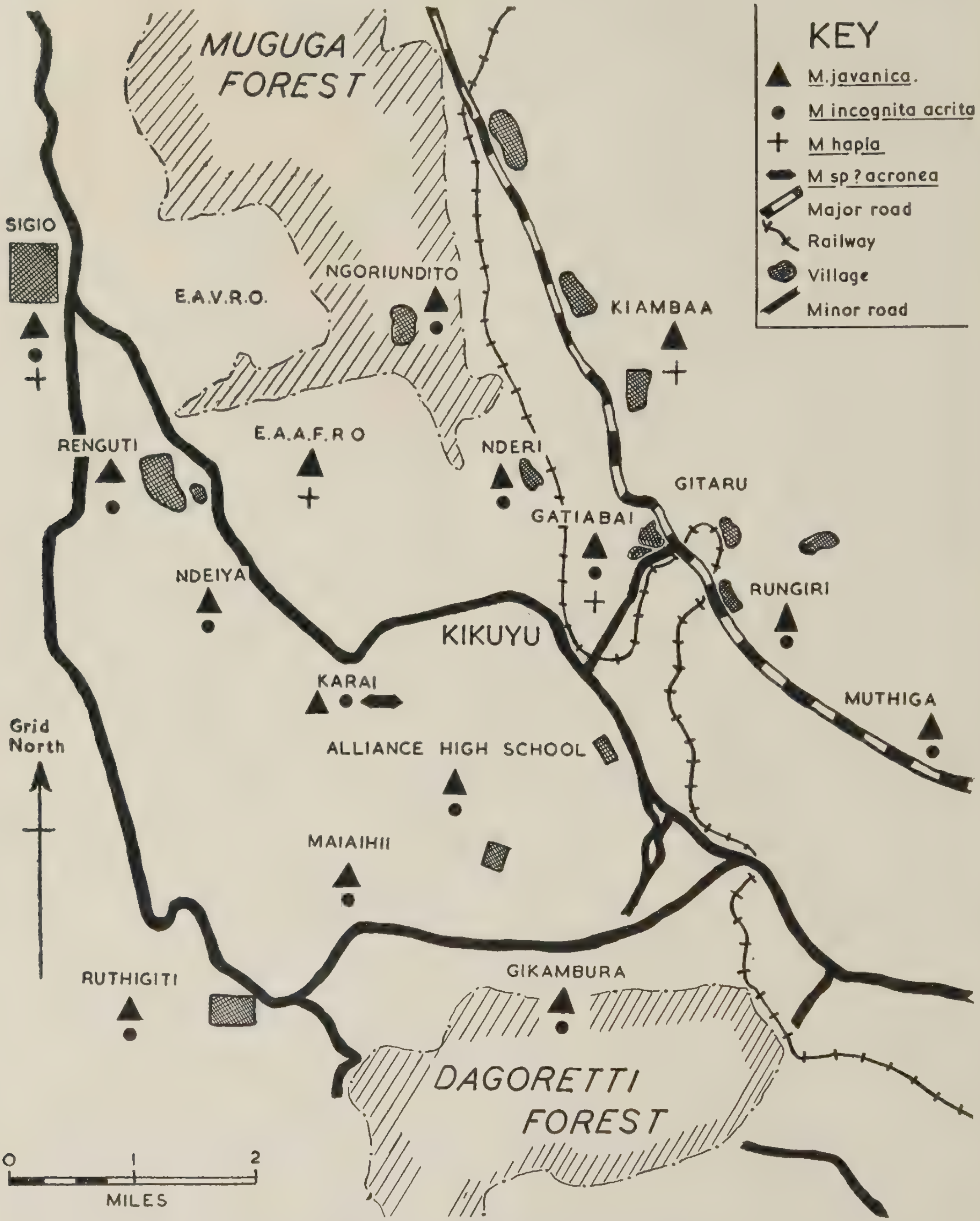
Each piece of cuticle so prepared is marked by a concentric pattern of striations corresponding to the annular striations of the cuticle of larval and vermiform stages of the species. These patterns are generally called "perineal patterns", but since they also enclose the tail end and lie outside the perineum they are perhaps better referred to as "posterior cuticular patterns" (Franklin and Whitehead, unpublished note). The form and characteristics of the mean "posterior cuticular pattern" provide the current basis for the identification of *Meloidogyne* spp. (Taylor, *et al.* 1955) and are used for identification of all species referred to in this series of papers. In general 20 to 25 patterns are cut for each population to be analysed because the range of variability of the posterior cuticular pattern is rather wide. Where root infestations are light it is not always possible to obtain this number.

KIKUYU DIVISION, KIAMBU DISTRICT, KENYA

The area selected was of approximately 50 square miles occupying the region 1° 10′ 30″—1° 18′ 30″ S. and 36° 35′ 30″—36° 41′ 00″ E. A map of the area and the distribution of *Meloidogyne* spp. within it is shown in Figure 1.

This region is for the most part heavily cultivated and has an altitude range of approximately 6,600 to 7,000 ft. The soils are dark red friable clays on which there are many smallholdings with mixed subsistence farming.

The general level of root infestations of susceptible species by root-knot nematodes was fairly heavy in the area surveyed, although locally and for given host plants there was



Root-knot nematode surveys of cultivated areas in East Africa some variation in the degree of attack. Uncultivated species growing at the edge of a swamp were not attacked.

The frequency of attack was also found to vary considerably. On the heavier clay soils and after heavy manurial applications there appeared to be a lower incidence of root infestations than on the lighter or unmanured soils. Within the area, wattle, brassicas, pepper, pumpkin and marrow, tomato, tobacco and dwarf bean root systems were very commonly attacked by *Meloidogyne* spp., sweet potato, maize and banana rarely, or not at all; *Cajanus cajan, Chenopodium murale, Erlangea cordifolia, Lablab niger, Leucas mollis* and *Solanum nigrum* were commonly attacked uncultivated hosts.

THE ROOT-KNOT NEMATODE FAUNA

In the range of plants studied four principal root-knot nematodes were found—*Meloidogyne javanica* (Treub, 1885) Chitwood, 1949, *M. incognita* var. *acrita* Chitwood, 1949, *M. hapla* Chitwood, 1949, and *M. sp.* ? *acronea* Coetzee, 1956. A few posterior cuticular patterns were not readily identified as there were insufficient of these forms.

M. javanica and *M. incognita acrita* were found in almost every locality sampled, as can be seen in the map. The former is the more frequently encountered generally, though in pepper the common species is *M. incognita acrita, M. javanica* being rare. In tomatoes *M. incognita acrita* was often to be found in large numbers, but in other host plants it was apparently less prolific. *M. hapla* was rare, except on pyrethrum, although it has been accredited elsewhere (Sasser, 1954; Martin, 1958) with a wide host range, including many of the hosts grown in the area.

Sex Ratios

While female root-knot nematodes are readily obtained from infested roots it is generally more difficult to obtain males in large numbers. This is currently thought to be due to suppression of the numbers of males produced in the life-cycle associated with the adoption by several species of *Meloidogyne* of parthenogenesis.

In this investigation the recovery of males from root systems heavily attacked by *M. javanica* and by *M. incognita acrita* was variable, but while most plant species yielded a small number of males or even none at all, *Leucas mollis* yielded large numbers of males even when the roots showed only slight galling. The nature of the gall tissues and the response of larvae to their specific tissue environment may be responsible for this. Further investigation of this phenomenon is envisaged since it may shed further light on the life-cycle of *Meloidogyne* spp. and also provide a simple method of obtaining large numbers of males, otherwise rare, for morphological variability studies.

Root Multispecies

The two tables show that the occurrence of two or more species of *Meloidogyne* on the same root system (conveniently called a "root multispecies") is a fairly common phenomenon. *M. javanica* and *M. incognita acrita* were often to be found on the same root system and on a wide range of hosts.

Minz and Strich-Harari (1959) investigated the cohabitation of *M. hapla, M. incognita acrita* and *M. javanica* on tomato roots by inoculation experiments. They showed that these three species could live concurrently on the same tomato root system. They claimed to have found several species of *Meloidogyne* even in the same root gall and to have demonstrated a different dominant species during each growing season: in summer it was *M. incognita acrita*, in autumn *M. javanica*. Unfortunately their published evidence is inconclusive and it is not possible to deduce these latter conclusions from it, although it would appear that in different seasons the rate of development of the females of the two species is different.

In this survey there was no constant root multispecies pattern for any given host plant, although they were collected in one season. This would seem to show that other factors may be equally or more important than seasonal change in affecting the relative population levels of the members of a root multispecies in this region.

New Host Records

The tables indicate 26 new host records of given *Meloidogyne* spp.

SUMMARY

A root-knot nematode survey in Kikuyu Division, Kiambu District, Kenya, revealed four root-knot nematode species. Of these *M. javanica* and *M. incognita acrita* were found throughout the area.

Crops and weeds in the area were subject to fairly heavy root-knot nematode infestations.

Root multispecies are common in the area, especially with *M. javanica* and *M. incognita acrita.*

ACKNOWLEDGEMENTS

The authors are very grateful to Miss D. M. Napper and Mr. R. Polhill of the East African Herbarium, Nairobi, for identification of weed species, and to Mrs. M. A. Ledger, Assistant Nematologist, E.A.A.F.R.O., for preparation of the map. Thanks are also due to Mr. R. M. Scott, Soil Survey Division, E.A.A.F.R.O., for information on the soils of the area.

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TABLE I—*Meloidogyne* SPP. OF CULTIVATED HOSTS

HOST	*Meloidogyne* spp. present	No. posterior cuticular patterns identified	Root multispecies	No. of localities
Acacia mollissima (black wattle)	A	121		9
	B n.r.	2	2(A+ B)=27·2	2
	D	1	1(A+ D)=7·1	1
Ananas sativus (pineapple)	A	3		1
	D* n.r.	5	1(A+ D*)=3·5	1
Brassica oleracea var. *botrytis* (cauliflower) ..	A	21		1
Brassica oleracea var. *capitata* (cabbage)	A	162		10
	B	3	1(A+ B)=5·3	1
	D	3	1(A+ D)=12·3	1
Capsicum frutescens (pepper)	A	3		1
	B	73	1(A+ B)=3·2	6
Chrysanthemum cinerariaefolium (pyrethrum) ..	A n.r.	1		1
	C	36	1(A+ C)=13·1	3
Cucurbita pepo (vegetable marrow and pumpkin)	A	134		10
	B	16	2(A+ B)=6·8	3
Eucalyptus sp. (Blue gum)	A	6		1
Ipomoea batatas (sweet potato)	A	3		1
	B	1	1(A+ B)=3·1	1
Lycopersicon esculentum (tomato)	A	155		10
	B	81	2(A+ B)=21·12	5
	D	1	1(A+ B+ D)=4·24·1	1
Nicotiana tabacum (tobacco)	A	116		8
	B	1	1(A+ B)=15·1	1
	D	1	1(A+ D)=12·1	1
Phaseolus vulgaris (dwarf beans)	A	134		11
	B	29	4(A+ B)=32·28	5
	D	2	1(A+ B+ D)=13·1·2	1
Solanum tuberosum (Irish potato)	A	23		2

KEY TO TABLES 1 AND 2—

n.r. indicates new host record.

Root multispecies are mixtures of species of *Meloidogyne* on single root systems. The number in front of the brackets denotes the number of root systems showing that type of root multispecies. A = *M. javanica*, B = *M. incognita acrita*, C = *M. hapla*, D = *M.* sp., D* = *M.* sp. ? *acronea*. The total number of patterns of each type for the total root multispecies are given on the right side of the equation. Thus for *Acacia mollissima* there were two root systems showing a multispecies of *M. javanica* and *M. incognita acrita* and in all there were 27 patterns of *M. javanica* and two patterns of *M. incognita acrita.*

TABLE 2—*Meloidogyne* SPP. OF UNCULTIVATED HOSTS

HOST	*Meloidogyne* spp. present	No. posterior cuticular patterns identified	Species mixtures on single root systems	No. of localities
Abutilon mauritianum	A n.r.	40		3
	B n.r.	17		1
Achyranthes aspera	A	5		1
Aspilia sp.	A	17		2
	B n.r.	4	1(A+ B) = 11·4	1
Cajanus cajan	A	58		5
	C n.r.	4		1
Chenopodium murale	A n.r.	77		7
	B n.r.	5	1(A+ B) = 7·5	1
Chenopodium opulifolium	A	8		1
Cluytia mollis	A n.r.	15		1
Conyza steudelii	A n.r.	5		2
	B n.r.	18		1
Erlangea cordifolia	A n.r.	178		12
	B n.r.	7	2(A+ B) = 24·7	2
Foeniculum vulgare	A n.r.	6		1
Gynandropsis gynandra	A n.r.	8		1
	C n.r.	1		1
Indigofera arrecta	A n.r.	4		1
	B n.r.	10	1(A+ B) = 4·10	1
Indigofera bogdanii	A n.r.	16		1
Lablab niger	A	99		9
	B n.r.	27	1(A+ B) = 10·16	2
Leucas mollis	A n.r.	71		8
	B n.r.	33	5(A+ B) = 29·32	8
	D	1	1(A+ B+ D) = 22·1·1	1
Lippia javanica	A	16		1
Sida schimperiana	A n.r.	13		1
	B n.r.	21	1(A+ B) = 13·2	3
	D	1	1(B+ D) = 9·1	1
Solanum nigrum	A	158		11
	B	6	1(A+ B) = 21·1	2

REVIEW

SOIL AND LAND USE SURVEYS, by the Regional Research Centre of the British Caribbean. Obtainable from the Imperial College of Tropical Agriculture, Trinidad, B.W.I.

(7) Jamaica, Parish of Clarendon, by T. F. Jones, 33 pp. and map, price 20*s*.

(8) Jamaica, Parish of St. James, by R. W. Price, under the direction of T. A. Jones, 26 pp. and map, price 12*s*.

As with the other reports in this series these reports summarize the climate, geology, ecology, and agricultural practices in these parishes, with detailed descriptions of soil genesis and profile characteristics, soil classification, physical properties, land use, and recommendations for the improvement in land use.

FIELD IMMOBILIZATION OF SOME EAST AFRICAN WILD ANIMALS AND CATTLE–I

By Lee Merriam Talbot, Ecologist, Foreign Field Research Programme, United States National Academy of Sciences—National Research Council, assisted by Martha Hayne Talbot on Serengeti-Mara Wildlife Research Project

(Received for publication on 8th August, 1960)

An effective method for immobilizing wild animals and livestock in the field has long been a goal for workers in the wildlife and livestock industries. For the veterinary officer and livestock raiser, such a method would facilitate handling, shipping, or treating of wild or unruly stock. For the wildlife biologist and game manager, it would have three principal applications: in the capture and translocation of animals from one area to another; in the inoculation of wild animals against disease; and in the capture of wild animals for weighing, measuring, marking, and blood and parasite sample collection, so that after release their movements, social behaviour, growth rates, and condition changes may be traced. This last function is an important part of our study into the ecology of East African plains wildlife.

After experimenting with several more conventional methods of animal capture, we have adopted the injection of an immobilizing drug as the most practical method for the habitat conditions and wildlife species involved in this study. The successful application of this method of field immobilization opens new horizons for the workers concerned—especially Game, Parks, and Veterinary personnel in East Africa. However, relatively little information has been available on the application of immobilizing drugs to wildlife, and on the techniques of delivering the drugs to the animal. To develop this method as an efficient and effective aid to our study, we have had to put considerable time and effort into research on techniques and drugs.

To date we have fired nearly 1,000 shots out of various types of drug-delivering weapons both in development work on target ranges, and in the field; we have darted 203 wild animals of 11 species, plus roughly half that number of cattle and captive wild animals. These dartings have involved experiments with five immobilizing drugs. In addition we have experimented with tranquilizing drugs on cattle and four species of wildlife, and using both immobilizing and tranquilizing drugs, we have translocated 15 individuals of three species of wild animal.

Our research is continuing and additional data will be published, as appropriate, in the form of other parts in this series. This report presents part of our findings to date. It is divided into two sections: the first describes the techniques of delivering a drug into an animal in the field, and the second gives the effects of the drugs on cattle and various species of wild animals.

DELIVERY

In this section the three aspects of the problem are considered in turn: A weapon to propel the projectile; the projectile which introduces the drug into the animal; and methods of approaching the animal to get within range of the propelling weapons.

Weapons

Experiments with various weapons have been carried out, both under controlled conditions on a target range, and under field conditions. The weapons used include long bow, cross bow, .22 calibre rifle, Palmer CO_2 powered dart rifles and pistol, and a powder charged dart rifle. All but the .22 rifle fired some form of a dart which is intended to inject the drug into the target animal on impact.

The long bow was found to be unwieldy, especially when shooting from a vehicle, and was discarded in favour of the cross bow. This is a less bulky weapon which can be accurate shooting darts to ranges considerably over 50 yards. It is currently in use by Mr. B. Carter of the Kenya Game Department, who reports successes using the bow on rhinoceros and giraffe (Carter, 1960A, 1960B, 1960C). For our uses on plains wildlife it appeared that a rifle or pistol would be superior to the crossbow from the standpoints of speed and ease of handling, loading and shooting, and control of the dart. Consequently most of our work has been directed towards these weapons.

The basic weapon used is the Palmer Cap-Chur Gun, an air gun manufactured for livestock and game capture by the Palmer Capture and Equipment Company, Atlanta, Georgia, U.S.A. There are two versions, a rifle and a pistol. Both are powered by capsules of compressed CO_2.

These weapons are entirely satisfactory for use on livestock at close ranges. However, successful use of these weapons on wildlife under field conditions is a difficult and complicated process. The trajectory, and therefore accuracy, depends on: the size and load of the dart projectile; condition of dart; air temperature; weapon temperature; wind; altitude; number of shots already fired from the CO_2 capsule which provides the propulsion; precise distance to target; cleaning and preparation of weapon. When proper attention is given to all these factors the accuracy within the given range is most satisfactory.

Both the rifle and pistol have an effective maximum range of about 40 yards. After considerable experimentation and preparation, when it is operating well our rifle has an effective range of 40-50 yards, and a maximum range of 60 yards in still air. Under windy conditions the effective range of either gun is very greatly reduced.

The pistol has the same accuracy and essentially the same effective range as the rifle, yet it is far more convenient to carry and much easier to fire from a moving vehicle. Using only the pistol, from a moving vehicle, in the past three months we have scored an overall average of over 80 per cent hits on wild animals, moving and still, at ranges up to 40 yards, hitting as many as 15 animals a day.

It is often not possible to approach plains wildlife outside of parks to within ranges of 50 yards, and get standing shots at them. To increase our range we have experimented very extensively with various methods of propelling the dart with a powder charge. The result is a weapon which shoots the dart with about 80 per cent accuracy to ranges of over 90 yards. The power comes from a hand-loaded shotgun cartridge. We empty the original load, leaving the primer, then reload it with slow burning rifle powder. A barrel with bore the size of the Palmer projectile darts (roughly .500 calibre) is inserted into a 12-bore shotgun equipped with telescope sights. The current weapon is the result of weeks of field and range work in co-operation with the Kenya Game Department, Central Firearms Bureau, Nairobi, and Nairobi gunsmith Hamid Walimohamed. The original barrel and idea came from the Palmer company, via Dr. Helmut Buechner, American wildlife biologist from Washington State University who worked in Uganda under Fulbright and National Science Foundation grants, and Dr. Anthony Harthoorn, Department of Veterinary Physiology, Makerere College, Kampala, Uganda. Accuracy depends on extremely critical preparation of the cartridges, the type and amount of powder, dart preparation, estimation of range and evaluation of wind conditions. Accuracy-wise the powder gun is most satisfactory. However, the increased stresses on the darts, both on firing and on impact with the animal, necessitate substantial modification of the dart to assure its holding together and operating satisfactorily. This factor, plus the time required for hand loading, etc., render the gun's use economical at present only on those species which cannot be approached closer than 40 yards by a moving vehicle. (*See* below, under *Approach*.)

Projectiles

The basic projectile is the Palmer Cap-Chur Syringe. This is a syringe in a form of a dart which automatically injects its load of drug into the target (Crockford *et al.*, 1958). The dart consists of an aluminium tube with a needle at the front end and a plug at the rear end fitted with a nylon or wool "skirt" to provide stability in flight. The immobilizing drug is placed in the front end, behind which is a rubber plunger, hollow on the rear end. A tablet of soda is placed in the hollow, sealed in by a brass plug, and a weak acid fills the remaining space. The impact from firing the gun knocks out the brass plug, allowing the soda and acid to mix, forming gas. This gas forces the plunger forward, ejecting the drug through the needle.

To ensure proper action extremely careful cleaning and preparation is necessary, amounting to about 15-20 minutes per dart. A few darts should be tested after each batch is prepared to ensure proper function as strengths of the batches of soda tablets and acid vary, and other conditions such as temperature may affect the dart's operation. Once prepared the darts can only be relied upon to function properly for a short time, never more than two days and usually only one.

Darts come in sizes from 1 c.c. (about $1\frac{5}{8}$ in.) to 10 c.c. ($5\frac{1}{8}$ in.). In our experience, with the powder gun best ballistic results are obtained with the 5 c.c. dart, while the Palmer pistol and rifle, the 3 c.c. dart is best, followed by 2 c.c. and 5 c.c.

The needles provided by the Palmer Company come in a variety of sizes ranging from ⅝ in. to 2½ in. Under ideal conditions the needles used should be long enough to ensure deep penetration of the drug into muscle. For cattle, large wildebeeste, eland, etc., needles from 1½ in. to 2 in. in length are most effective. However, for field work we have found the shorter needles far more satisfactory. A longer needle has more tendency to break off on impact; less chance of allowing the dart to stick in the animal on a glancing or oblique blow (often secured when shooting from a moving vehicle or at a moving animal); and it will cause less tissue damage and consequent distress on the part of the animal. At maximum range 90 per cent of our hits with long needles result in broken needles or darts not sticking; while with short needles over 90 per cent of the hits stick and function perfectly. For everything from bush pig and Grant's gazelle to African buffalo and eland we have found the 1⅛ in. needles most satisfactory. The same may be used for Thomson's gazelle, but the ¾ in. needle is more desirable.

These needles come equipped with collars or barbs to hold the dart in the animal. For short-range shots at cattle or thick-skinned animals, the larger collars, bevelled on both sides, are adequate. However, on long-range or moving shots at wild animals a barb or cone (a collar bevelled on the forward end and flat on the rear) has proved absolutely necessary: darts having needles with the ordinary collar bounce out on impact or drop out before the drug has been injected.

Since the soda-acid reaction starts when the gun is fired, there is a certain amount of blow-out of the contents of the dart in the air at ranges over roughly 25 yards. At ranges of 50 to 90 yards this blow-out becomes quite extreme and renders the delivery of a precisely measured amount of drug quite impossible. It is possible to overcome this fault in part by using two rubber plungers, the one with the soda and brass plug reversed, so that the reaction starts on impact with the animal. Although this method usually functions properly, it uses up a significant amount of the drug-carrying capacity of the dart in the case of the smaller and ballistically more desirable darts.

In any case the complete reaction takes up to 20 or more seconds (the time depends on the dart preparation) during which time the dart may fall out or be knocked out of the animal, so that the full dose is not delivered. This is especially likely when shooting at long ranges, when the dart or needle may break more or less on impact.

A new development which cures the blow-out and fall-out problems of the soda-acid reaction is the Palmer Company's explosive cartridge for the syringe. This cartridge is about the size of a .22 shell, and contains a small powder charge and an integral firing pin. The cartridge fits in the syringe in the space formerly occupied by the soda-acid mixture. On impact with the target, momentum forces the firing pin forward exploding the charge. This in turn forces the rubber plunger forward, expelling the drug under high pressure.

We have used these explosive injectors successfully on cattle and on five species of African animals, from hyena to African buffalo. On dissection of ten sites of injection by the explosive injected syringe, we have found the following: in thick muscle, such as the rump, where the drug left the needle there is tissue damage for an inch or so resembling the passage of a .22 bullet. There is no haemorrhage and the damage is considered to be no worse than that caused by injection of vaccine in cattle with the large-bore hypodermic needles. In layered muscles, such as that of the upper neck, where the drug passed through the intermuscular tissues there is severe haemorrhaging, as much as 40 square inches per layer. However, no complications other than a temporary slight swelling have been noted in cattle and wildebeeste shot in the neck with this charge.

These explosive injectors are easy to handle and use, and cleaning and preparation of the syringe is much faster and easier than when using the soda-acid method. Blow-out is eliminated completely. The explosive injection also produces more rapid absorption of the drug into the animal's circulation—the speed of reaction being increased by 20 to 30 per cent over that produced by injection by the soda-acid syringes, under controlled conditions.

When loaded with an explosive injector, the dart barrel must be filled completely with drug and distilled water if necessary. In every case when the dart was not completely filled and an air space remained, the dart was blown back out of the animal. This has never happened with a correctly filled dart.

The explosive injector cartridge must be wedged very tightly between the plunger and tail of the dart, or the plunger may not be forced all the way down the barrel of the syringe.

The one limitation on use of the explosive injectors is with moving shots which result in oblique hits. The explosive injectors require a fairly direct hit to cause the integral firing pin to strike the charge with sufficient force to fire it. The glancing blows often secured when shooting at a running animal or from a rapidly moving vehicle fail to detonate the charge in about three-fourths of the shots. Consequently it is most satisfactory to use the explosive injected darts for standing and long distance shots and the soda-acid darts for close moving ones.

A small calibre bullet is far more accurate and easy to use than a large syringe. Accordingly we have experimented with the possibilities of using drugs inserted in such a projectile.

To determine the effects of these projectiles on a live animal, we used, as a target, a freshly slaughtered steer, provided by the Kenya Veterinary Department's Kabete Laboratory. Shots were taken at various parts of the body from varying ranges. These were then dissected out to determine the penetration and effect of the bullet.

The bullets were .22 calibre long rifle slugs, propelled by three types of .22 charges: short, long rifle, and long rifle "hi speed". The slugs were hollowed out to accommodate the immobilizing drug, the final result being a thin shell of lead with core of drug. Strong dye was used to simulate the drug contents in the bullets to facilitate tracing the drug distribution on dissection of the animal.

The best results in terms of accuracy and controlled penetration were obtained by using a .22 long rifle charge, at ranges of 40-80 yards. At greater range a long rifle hi-speed charge appeared better.

The lead shell must be very thin, to assure immediate and shallow mushrooming. However, care must be taken to hollow out the shell evenly, as any irregularities result in an unbalanced bullet which tumbles in flight.

The thick muscle of the rump is the most desirable target. The tissue damage from the ½ to 2½ in. penetration of a well hollowed-out bullet is not felt to be dangerous, properly placed; nor is the bullet remaining in the animal considered especially serious, as we have found wild animals with much larger calibre bullets which had evidently been carried in various parts of their bodies for some time with no ill effects.

A fluid-filled bullet, the tip sealed by wax, will usually deliver the contents properly. However, a powder-filled shell is more consistently effective. In this case the drug should be in powder form and mixed with hyaluronidase to hasten absorption. Even more desirable would be a complete bullet made of the drug with hyaluronidase. However, it would require considerable experiment to develop a drub-based substance which would withstand the initial shock and heat of firing and still be absorbed immediately when in the animal.

The capacity of a .22 calibre slug is extremely limited, consequently any immobilizing drug used within it, or even within a slightly larger calibre bullet must be in a highly concentrated form. We have postponed further experiments until a successful drug is available to us in sufficiently concentrated form.

Approach to Animal

With the limited effective range of the capture weapons, the initial problem one meets in their use is approaching the target animal. Below is a brief summary of the important points, based on the past year's field work with East African plains game.

Our attempts to stalk plains animals on foot and also to drive herds of animals, or individuals past a person hiding with a capture gun have had limited success. Approaches on foot have been made successfully, however, on other types of animals in different habitats, rhino in bush country, for instance.

We feel it is most desirable to approach plains animals from a vehicle because efficiency of time is always an important consideration, and approaches on foot are usually unreasonably time consuming. It is usually easier to approach African plains animals in an automobile than on foot. The animal will have to be followed up after darting, and a vehicle is necessary for this since the animal may cover considerable ground between the shot and the time when the drug takes effect. The higher line of vision afforded by a vehicle facilitates spotting and marking down the location of darts which missed, a desirable procedure in view of the expense of darts.

The closest approach is made in a vehicle which—

Makes a smooth approach. Sudden lurches, bounces, or changes of speed frighten the animals.

Avoids driving directly towards the animals, or turning towards them.

Has no shiny or reflecting surfaces.

Has headlamps and any spotlamps covered.

Has no humans in plain sight, and no sound of human voices.

Has a minimum of humans in it.

Does not make excessive noise through rattling and clanking.

Exhaust noise, if constant, seems of little importance.

It is often possible to drive slowly past or through a herd at ranges of from 25 to 40 yards. Stopping to bring a rifle into play usually causes the animals to bolt immediately, but they only walk or trot relatively quietly if the car continues straight and moderately slowly (5 to 25 miles per hour, depending on conditions). The most successful capture work we have done has involved using the capture pistol with this type of approach. The animal is shot from the moving car, which then continues straight on for about 100 yards to avoid disturbing the herd by stopping close by. The animal shot usually remains with the herd, continuing grazing or standing until it drops. This technique is fast and efficient and involves a minimum of disturbance of the animals. We have used it with about 80 per cent of the approaches resulting in capture of wildebeeste, topi, Grant's gazelle, Thomson's gazelle and zebra.

Another pistol technique involves chasing an animal with a vehicle and shooting when close enough. Ideally, using a fast vehicle on fairly smooth ground, an animal can be darted before it has run 100 yards. The vehicle drives away at speed and the animal returns to the herd, which after the initial milling about returns to grazing or standing. Surprisingly little disturbance of the animals is involved in this method. Longer chases are not desirable as they result in considerable disturbance or distress to the animal involved, as well as possible damage to the chasing vehicle and its occupants. The quick chase technique has worked with over 90 per cent of the approaches resulting in capture of wildebeeste, zebra, topi, Thomson's gazelle, Grant's gazelle, and hyena.

When no disturbance has attended the darting and immobilization is complete the animal involved apparently does not connect the individual and his vehicle with the experience, and the animal can be approached subsequently for identification and observation. To accomplish this it is important for the animal to be left alone when it is recovering. Backing the vehicle 40-60 yards away is usually sufficient. Otherwise when the animal awakens and finds people and vehicles near him he becomes distressed and it is subsequently extremely difficult to get anywhere near him.

DRUGS

This section presents the general principles regarding the effect of drugs and application to animals; our methods used in field immobilization and paddock experimentation; the characteristics of each drug and its reactions on the species of animal involved; and the results of translocation experiments with wild animals.

Although the successful use of immobilizing drugs on a few individuals or certain species of wildlife, have been published (Buchner *et al.*, 1959, 1960A, 1960B, 1960C, 1960D; Crockford *et al.*, 1957A, 1957B; Hall *et al.*, 1953; Post, 1959; Lock and Harthoorn, 1959A, 1959B; Pistey and Wright, 1959; Craighead *et al.*, 1960; Rauch *et al.*, 1960), there is, as yet, no immobilizing drug which has been safely or successfully applied to any large numbers of animals of a wide variety of species. Each drug has a different reaction; each species of animal appears to have a different resistance to any given drug; and a number of factors influence the effect of a given drug on different individuals of any particular species. Consequently it does not appear valid to generalize on the effects of any drug on the basis of experiments with a few specimens.

In the course of our work to date we have hit a total of 203 wild animals with capture darts fired from powder and CO_2 guns. These represent individuals of 11 species, although the central animal of our study is the wildebeeste and we have given it most attention. In addition we have experimented with simulated controlled field conditions injecting immobilizing drugs into about 100 cattle and captive or tame wild animals. Translocations, involving the use of tranquilizers after initial immobilization, transfer by lorry or Land-Rover, and subsequent release into a paddock or new wild habitat have been carried out with 15 animals of three species.

The drugs used fall into two main categories, immobilizers and tranquilizers. In our work the purpose of the immobilizing drug is to render an animal incapable of movement, and preferably, unconscious of his surroundings or what is being done with him. The immobilizing drugs whose effects are described below are: Succinylcholine chloride, Nicotine, Sernyl, Tubocurarine, and Flaxedil.

Tranquilizing drugs are slower acting than immobilizers, and they do not necessarily render an animal incapable of movement. Depending on the dosage, they produce effects varying from slightly reduced reaction to an animal's environment (e.g. a wild animal may be slightly less disturbed by the presence of humans) to a deep sleep. After an animal has been captured by immobilizing drugs, the tranquilizers may be used to maintain it in an easily manageable condition for longer periods of time—up to 12 or more hours. Tranquilizers are particularly useful in the translocation of wild animals or shipping of livestock. The tranquilizers described below are Largactil and Diquel.

As a general rule, the effect of any given drug on an animal depends on the following factors.

Placement of the injection.—The safest and best location is usually in the thick muscle of the rump, back, shoulder or neck. Subcutaneous injections anywhere in the body usually require a much longer time for the drug to be absorbed, and therefore for reaction to take place. There is conflicting evidence regarding the effect of interperitoneal or interplaneural cavity injections on the speed of reaction.

The Animal's Movements Following Injection.—Usually drugs must be absorbed into the circulatory system to obtain their reaction. As exercise speeds circulation, a quicker and sometimes more complete reaction may be expected from an animal which runs following an injection than from one which stands quietly. However, a frightened animal may have a much greater resistance to a drug than an unfrightened one, requiring up to three times as long for the drug to take effect.

Weight of the Animal.—Dosages are given in terms of some unit of drug per pound or kilo of body weight, as the effect of all the drugs so far used is directly proportional to the weight of the animal. With most drugs, one must estimate quite accurately the weight of the animal to be darted and base the dosage on that estimate to achieve satisfactory results.

Sex, Age, and Condition of the Animal.—In some cases females require a different dosage per pound of body weight than males. In general, with immobilizing drugs, young animals, especially well muscled animals, and pregnant females require a higher dose per pound than older or poorer animals. With tranquilizing drugs, young animals usually require a lower dosage per pound than adults. An old or sick animal may be killed by a dosage that produces only a slight reaction in a young healthy one. There is some evidence that the time of last feeding and drinking may affect the reaction.

Individual Variation.—Just as the reaction of humans to a given drug may vary greatly, some individuals having greater and some lesser resistance to it, there are considerable variations in drug resistance between individuals in any wild or domestic species. In our experience about one animal in 15 has an aberrant reaction to any given drug.

Following placement of a dart, it is most desirable to move some distance away, to avoid frightening the animal further. Unless the dart strikes a nerve or bone, or is visible to the animal, there is usually no more reaction to it than to a tsetse fly bite, and if undisturbed the animal will return to its herd, or its activity prior to darting. It is essential, however, to keep the animal in sight so that it may be approached quickly after collapse. To this end it may occasionally be necessary to try to herd the animal away from thick bush or rocks where observation or pursuit would be impossible.

After collapse, the animal should be approached quickly but carefully. In some cases complete immobilization may not occur for some minutes after initial collapse. In these cases the approach of humans frightens the animal and it may arise and run off, or injure itself in struggling to rise.

Once immobilization has occurred (the depth of immobilization depends on the drug) the animal should be placed on its brisket with head held upright. In the case of the zebra, bush pig, and all the ruminants immobilized except Uganda kob while under the influence of immobilizing drugs it is essential to avoid leaving the animal lying on its side or with its head flat, as in this position the animal is in danger of inhaling rumen or stomach contents and of abdominal bloating. The kob, alone among the ruminants we have observed will belch while lying prostrate and will not bloat or suffocate for periods of at least an hour (Buechner, 1960c). On the other hand, in the case of wildebeeste, topi, and Thomson's gazelle, death can result from lying immobilized on their sides for three to five minutes.

It is also important to cover the animal's eyes as long as it is being handled by humans. With some drugs the animals are capable of seeing what is going on for some time before co-ordination returns to their legs. An eye cover avoids unduly frightening the animal and running the risk of injury to humans or the animal in its attempts to escape before co-ordination returns.

Following initial recovery, and depending on the drug used, the animal should be kept under observation long enough to assure that there is no recurrence of paralysis or ataxia. After walking or running several hundred yards, a weakened animal may fall on its side and bloat or drown, or fall easy prey to hyenas or other predators.

Methods

Our procedure with an immobilized animal is to cover its eyes, roll it onto a canvas sling, weigh it, take standard measurements, collect blood and parasite samples as appropriate, and mark it for future identification. The weighing is accomplished by means of a telescoping derrick and winch mounted on the back of our Land-Rover, and a 1,120 lb. trade scales provided by the Kenya Veterinary Department. The whole procedure requires about 15 minutes.

The weights and measurements are extremely important. Without knowing precise weights it is only possible to make a rough guess as to the dosage delivered to an individual animal. It is not always possible to weigh every animal, but with the standard body measurements (shoulder height, heart girth, etc.) we can refer to our tables of weights and measurements and determine the weight with a satisfactory degree of accuracy.

The ideal drug for our purposes would immobilize an animal very rapidly, preferably in three to five minutes, and certainly no more than eight to ten minutes to prevent an animal which is frightened from covering too much ground and becoming lost to us before it drops. While down the animal should be completely immobilized for easy handling. After 15 to 30 minutes the drug effect should then wear off quickly and completely, with no after effects. Our investigations, therefore, have been aimed at finding a drug that has such an effect on wildebeeste. However, since the Game, Parks, and Veterinary Department uses for such drugs include the capture of animals for transport, we have also looked into longer-acting drugs and tranquilizers.

In view of the difficulties and time involved in getting shots at wild animals and (until the recent development of the explosive injectors) the uncertainties of delivering a precisely measured amount of drug, as well as the unavoidable variations in field conditions, we have developed a procedure for using domestic cattle under controlled conditions to determine the pattern of reaction of each drug. The dosage needed for a wild animal will usually differ from that needed for a cow, but the general pattern of reaction (the effect of varying dosages on the animal) will be much the same, so that after carrying out the cattle experiments, when we go after a wild animal, we know how to interpret its reactions in terms of the known pattern of reaction of any given drug.

The experiments were carried out between October, 1959, and May, 1960, at the Kenya Veterinary Department Laboratories at Kabete and the High Commission Veterinary Research Laboratories at Muguga. The animals were young European-type cattle. They were weighed and the dosages worked out precisely in terms of milligrams of drug per pound of body weight. Most weighed from 300 to 600 pounds, the approximate range of field weights of wildebeeste. Injections were intramuscular, either by Palmer syringe (soda-acid or explosive injectors) or by hand syringe with placement and timing made to simulate the dart injection. As with all of our field immobilizations, the reactions of the cattle were timed with stop watch and movements and reactions carefully noted.

Presentation of Drug Data.—In view of the number of drugs studied to date, the numbers and varieties of animals, and the wide variations in the drug effects on different animals, there is insufficient space here to present in full the many details of the animal reactions. These will be published elsewhere. Below is a summary of the conclusions to date regarding each drug. Table I shows the apparently effective dosages of the drugs as determined on ten species. There may be changes in detail of dosage as further experience is gained and there will be additions to the list of species.

TABLE I—APPARENTLY EFFECTIVE DOSAGES OF IMMOBILIZING DRUGS

SPECIES	Drug	Dosage;	Time to Collapse; min. from Injection	Time to Regain Feet; min. from drop	Antidote (Neostigmine)	Number of Animals on which dosage based	Remarks
		mg. per lb.			*mg. per lb.*		
European-type cattle	Flaxedil (*)	1·3–1·4	8 (3–13)	9–14(†)	0·04	—	Full recovery may take 2 hours.
	Sernyl	0·5	7	240 plus	None	—	Not fully immobilized.
Wildebeeste (*Gorgon taurinus*) ..	Nicotine	0·9–1·15	12	10–30	None	21	Collapse often follows violent exertion; recovery requires 2 hours.
	Succinylcholine chloride	0·031–0·032	11 (7–16)	38 (27–46)	None	45	Much individual variation.
	Flaxedil (*)	1·52–2·0(‡)	5·5 (3–8)	7 (3–9)(†)	0·05–0·067	15	
	Flaxedil(*)	1·18–1·82(§)	8 (5–12)	15 (5–23)(†)	0·04	26	50% recovery immediately, 50% require up to 3 hours.
Thomson's gazelle (*Gazelle thomsoni*).	Flaxedil(*)	1·3–1·5	7 (4–10)	15 (8–20)(†)	0·04	4	Recovery may require 30 min. additional.
Grant's gazelle (*Gazella granti*)	Flaxedil(*)	1·09–1·32	25	8(†)	0·04	3	Flaxedil at 1·6 mg./lb. would probably bring quicker drop.
Topi (*Damaliscus Korrigum*) ..	Flaxedil(*)	1·3	6·5	32(†)	0·04 initially 0·02 after 2 hours.	3	Full recovery requires 3 hours. Flaxedil at 1·2 mg./lb. possibly better.
Cape buffalo (*Syncerus caffer*)	Flaxedil(*)	1·3	10·5 (5–16)	10(†)	0·04	2	Full recovery 30 minutes later.
	Sernyl	Lethal at 0·5	—	—	None	1	
Eland (*Taurotragus oryx*) ..	Sernyl	Lethal at 0·68	—	—	None	1	
Bush pig (*Potamochoerus choeroptomus*).	Flaxedil	5·0	2·5	21	0·04(*)	3	Best dosage of Flaxedil appears 3·0 mg./lb.
Zebra (*Equus quagga*)	Flaxedil	Lethal at 1·0. Ineffective at 0·8.	—	—	—	9	Apparently not effective.
Uganda kob (*Adenota kob*) ..	Succinylcholine Chloride	0·159	3–7	40 (20–60)	None	7	

*Given with atropine at 0·1 mg. per lb. body weight to reduce salivation.

†When antidote given within 2 minutes after collapse.

‡Calves about 6 months old (averaging 172 lb.).

§Adults.

Succinylcholine chloride (suxamethonium chloride) is a neuromuscular blocking agent whose effects are irreversible except through action of the body's cholinesterase, hence an overdose is lethal. Succinylcholine chloride's effect on different species varies widely, ranging from consistently effective immobilization of Uganda kob to inconsistent, unsatisfactory immobilization of wildebeeste, where determination of effective dosages requires estimating animal's weights within 15 lb.; and speed, depth, and duration of immobilization are variable. Considering the irreversibility of reaction and variability of results, we do not consider succinylcholine chloride a desirable drug for general use, except on proven "ideal subjects" such as the kob.

Nicotine salicylate is an extremely caustic and poisonous substance. When injected, low dosages are an irritant or stimulant to violent exertion; intermediate dosages may produce immobilization, often following convulsions; high dosages are irreversible producing severe convulsions followed by death. Nicotine has been used successfully to immobilize domestic livestock (Anon., 1959B) but much less successfully on wildlife. We consider it undesirable for our purposes due to likelihood of injury and disturbance from convulsions and danger to humans.

Sernyl (Parke, Davis and Co., U.S.A.) produces anaesthesia in some animals through an apparently selective effect on parts of the central nervous system. It appears unsatisfactory for our uses on cattle, eland and buffalo, where no complete immobilization has been obtained, eventual collapse often following blind struggling which injured the animals, and the final result being ataxia of long duration or death.

Tubocurarine, an alkaloid or organic derivation, produces a neuromuscular block which can be reversed, within limits, by injection of neostigmine bromide or methylsulphate. Tests with two cattle appeared to bear out the advantages—safety and speed of reaction—claimed for the synthetic curare. Flaxedil (Anon., 1959) so further tubocurarine experiments were cancelled in favour of those with Flaxedil.

Flaxedil (May and Baker Ltd., England) is a synthetic curare-type drug whose action is similar to tubocurarine. It is not satisfactory for immobilizing zebra, however, with bush pig, cattle, and five species of wild ruminants, Flaxedil has proved a quick acting, effective immobilizer with a wide (twice the effective dosage) margin of safety. The antidote neostigmine is essential, but overdoses may be lethal. Following initial recovery the animal should be watched for signs of recurrent paralysis or ataxia. Therefore Flaxedil is not an ideal drug for field marking with quick release, although properly handled it is quite satisfactory. It is particularly well suited for use with tranquilizers in translocation.

Translocation of Wild Animals

After an animal has been captured by conventional catchers' methods or immobilizing drugs, if it is to be transported any distance the most satisfactory procedure is to tranquilize it. In our experiments with translocation we have used two drugs, Largactil (Chlorpromazine hydrochloride, produced by May and Baker Ltd., England), and Diquel (produced by the Jensen-Salsbery Laboratories, Inc., Kansas City, Missouri, U.S.A.). In all cases, the animals were first immobilized with Flaxedil delivered in a soda-acid syringe shot from the Chap-Chur pistol. They were blindfolded; given the antidote, neostigmine; then measured; given the tranquilizer; usually weighed; and placed in the back of the Land-Rover or lorry. The animals were transported from 6 to 30 miles over rough country, a process requiring up to four hours, then offloaded and released into a new wild habitat or an enclosure. The details and results are presented below by species:—

WILDEBEESTE CALVES—Eight animals about six months old, averaging 172 pounds weight.

Drug	Dosage	Reaction
	mg./lb.	
Diquel	0·56–0·57	Deep sleep for 3–4 hours. tranquilized, unable to rise for 6–7 hours.
Diquel	0·65–0·67	Deep sleep for about 6 hours, tranquilized, unable to rise for total of 8 hours.
Largactil	0·57 followed by 0·3 in 2 hours, + 0·3 in 4 more hours.	Deeply tranquilized, unable to rise for 18 hours.

WILDEBEESTE ADULTS—Four animals, averaging 481 lb. weight.

Drug	Dosage	Reaction
	mg./lb.	
Largactil	0·56	Unable to rise for 3½ hours.
Diquel	0·7	Unable to rise for 5½ hours.
Largactil	1·0	Unable to rise for 8½ hours.
Largactil	1·27 (in two doses, two hours apart).	Unable to rise for 5 hours, then moved a few feet and lay down again. Recovery about 12 hours after initial dose.

THOMSON'S GAZELLE—Two animals.

Drug	Dosage	Reaction
	mg./lb.	
Diquel	0·5	Unable to rise for about 6 hours, tranquilized for 10 to 12 hours.
Largactil	0·5	

GRANT'S GAZELLE—One animal

Drug	Dosage	Reaction
	mg./lb.	
Diquel	0·5	Unable to rise for 2 hours 45 minutes; sudden recovery.

The dosage rates and effects of Diquel and Largactil appear identical. Wildebeeste calves have lower resistance to tranquilizers than adults. Wildebeeste and Grant's gazelle have higher resistance to the drugs that Thomson's gazelle. All were manageable during translocation with the dosages given. However, ten or more minutes should elapse between injection of tranquilizer and any attempt to move the animal, to allow the drug time to take effect and to ascertain the degree of tranquilization. Tying the animals inside a canvas sling, with legs doubled beneath them, greatly facilitates handling and restraint. It is essential with deeply tranquilized ruminants to keep the heads up.

The tranquilizers also appear to act as a shock reducer for immobilized animals. In four cases, animals which were slow in recovering from the immobilizing drug (Flaxedil, followed by neostigmine) and which appeared to be having considerable difficulty in breathing, were tranquilized. In each case the breathing became normal within about ten minutes, and the animals recovered normally and completely after the tranquilizer wore off.

Conclusions.—Diquel and Largactil are both effective tranquilizers for wildebeeste, Thomson's and Grant's gazelle. They may be used safely in conjunction with Flaxedil, and apparently even have a buffering effect reducing the shock of the immobilizing drug. The degree and length of tranquilization can be adjusted by varying the initial or subsequent doses, and under the proper degree of tranquilization, the animals may be transported across very rough ground even in the back of a Land-Rover.

SUMMARY

An effective method for field immobilization of wild animals and livestock can be of great value to workers concerned both with wildlife and with livestock. The capture of wild animals for examination and marking is an important part of our current research into the ecology of plains wildlife in East Africa. We have devoted considerable time during the past year to develop an effective and efficient method for accomplishing this end. A portion of the results to date of this research is presented in this paper.

The method of capture adopted was injection of an immobilizing drug into a wild animal. Field and laboratory experiments were conducted with a variety of types of approach to the animal, of projectiles to inject the drug, and of weapons to propel the projectile, and the results with each are presented. Eighty to 90 per cent success has been achieved using a CO_2 powered pistol shooting an automatically injecting dart-syringe from a vehicle, either moving slowly past an animal or chasing it at high speed for a short distance.

Experiments have ben conducted with five immobilizing drugs (succinylcholine chloride, nicotine, Sernyl, tubocurarine, and Flaxedil), and one or more of these have been tried on 11 species of wild animals and on cattle. General principles regarding the use and effect of immobilizing drugs are presented. Table I summarizes the findings on ten species.

Experiments have been carried out using tranquilizing drugs (Largactil and Diquel) in conjunction with Flaxedil to facilitate translocation of wild animals. Using these drugs, Thomson's and Grant's gazelle and wildebeeste have been successfully moved cross country in Land-Rover or lorry.

Succinylcholine chloride and Flaxedil are the most successful immobilizing drugs tried to date for certain species. However both drugs have disadvantages and research aimed at finding more effective immobilizing drugs is continuing. Additional results will be published as appropriate.

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REVIEW

MANIOC IN AFRICA, by W. O. Jones, published by the Food Research Institute, Stanford University Press, Stanford, California, U.S.A., 1959, pp. 315, 15 maps and 10 illustrations. Price $6.75.

This book deals with almost every aspect of Manioc (Cassava) in Africa. The author discusses the introduction and spread of Manioc in relation to land, climate and people. He deals with methods of cultivation and preparation as well as local likes and dislikes. In particular he assesses the position of Manioc in a developing economy because over-reliance on a starchy staple of low protein content may cause difficulty in maintaining a population in full vigour.

This book is easy to read and it should appeal to all farmers and agricultural officers in the tropics, not only to those of tropical Africa. It should be in the library of every Department of Agriculture, for its long lists of references at the end of every chapter, and even to the appendices, are likely to be extremely useful to the agronomist.

EFFECT OF MANAGEMENT ON INCREASING CROP YIELDS IN THE LAKE PROVINCE OF TANGANYIKA

By J. E. Peat and K. J. Brown, Empire Cotton Growing Corporation, Ukiriguru, Lake Province, Tanganyika

(*Received for publication on 6th June, 1960*)

The responses of rain-grown cotton in the Lake Province of Tanganyika to applications of organic manure and inorganic fertilizers, compared with the responses to land-resting and rotational treatments, are to be published in two papers. Notes are given here on other practices which can greatly influence crop yields but are of more local interest.

It would probably here suffice to say that the results described are from the hill sands of Ukiriguru—with a reference to the Ukiriguru "Mbuga" Valley bottom clay soils—and from two soil types at Lubaga, near Shinyanga, the friable black loam soil "Ibushi", and the cemented hard-pan soil "Ibambasi".

The annual rainfall on Ukiriguru has a range from 20 to 53 in. The period of rainfall generally extends from late October to mid-May, with cotton planting in December. Often there is a gap in the rainfall during the mid season and this may occur any time from late January until late March, but it is the March droughts which are most feared, as that is the time at which the cotton is fairly advanced in growth.

At Lubaga the rainfall tends to be lighter and to cut off earlier in the season, although storms of 2 in. or over are more frequent there than at Ukiriguru.

TIE-RIDGING

Ukiriguru

At Ukiriguru, and generally in the hill sand country, cultivation is on 5 ft. ridges. Weeds are scraped into the furrow and a new ridge is built by hand hoe over the previous year's furrow, thus burying the weeds. No hill sand cultivation is on the flat; if it were, there would be erosion and soil loss. Where, for demonstration purposes on Ukiriguru, cotton is flat planted on the hill sand soils, in many years there is a big drop in yield compared with planting on ridges, all the greater compared with planting on tied ridges. Ridging without tying does not stop wash down the furrow and therefore loss of the finer soil fractions.

As a routine practice on Ukiriguru and in the district trials, cross ties are made in the furrow every 8 ft. or so, making a series of rain-holding basins, Plate I. This is the complete answer to soil erosion; further, the rain being held in the basins greatly adds to the effectiveness of the rainfall in droughty periods and increased crop yields result. When first made the ties are not compacted and can break in early-season heavy rain; they then have to be remade, but as the season progresses they consolidate and set hard.

The results from Ukiriguru, Trial 16, comparing tied with non-tied cultivation, of cotton and bulrush millet rotated in alternate years, are given in Table I. The mean increase for cotton, over 11 seasons, as a result of tying well-made ridges compared with ordinary ridges not tied, was 151 lb. seed cotton/acre, and for bulrush millet over ten seasons a mean increase of 95 lb. grain/acre.

The largest cotton increase was in 1952/53, 355 lb. seed cotton/acre, an increase of 48 per cent. This was a bad season for rainfall distribution, December being dry and a drought from mid-January until the end of February. The bulrush millet increase in that season, as a result of tying, was only 10 per cent. This illustrates the differing responses of the two crops which is partly due to their stage of growth in the mid-season. The recommended month for cotton planting is December and flowering starts in February. Bulrush millet is planted from late in January until mid-February; the young bulrush millet plant therefore in general suffers less from mid-season droughts.

In 1948/49, with poor rains in January and February, and a drought in March, cotton yields were low; the cotton yield increase as a result of tying was 263 lb. seed cotton/acre, an increase of 82 per cent; for bulrush millet the untied treatment was practically a failure; the tied treatment, though producing a poor yield, gave over three times the yield of the untied treatment.

TABLE I—UKIRIGURU TRIAL 16. TIE-RIDGING. YIELDS LB./ACRE SEED COTTON AND BULRUSH MILLET GRAIN

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	Mean
SEED COTTON												
Tied	854	1,201	583	435	1,037	830	1,103	941	1,465	1,137	1,106	972
Not tied ..	585	1,082	320	387	972	843	748	777	1,150	1,076	1,118	821
SE ±	34·7	35·7	21·5	18·7	48	17	37	28	39	53	32	
Yield Increases due to tie-ridging.	*+269 +46%	*+119 +10%	*+263 +82%	+48 +12%	+65 +7%	−13 −2%	*+355 +48%	*+164 +21%	*+315 +27%	+61 +6%	−12 −1%	*+151 +18%
BULRUSH MILLET GRAIN												
Tied	483	1,427	304	845	706	288	1,119	798	1,024	441	511	722
Not tied ..	460	1,090	90	908	620	342	1,018	719	804	486	359	627
SE ±	—	88·7	30·9	4·1	57	—	31	35	35	18	50	—
Yield Increases due to tie-ridging	+23 +5%	(Maize) *+337 +31%	*+214 +238%	−63 −7%	+86 +14%	−54 −23%	*+101 +10%	+79 +11%	*+220 +27%	−45 −10%	*+152 +42%	+95 +15%
	Wet year: good rainfall distribution.	Fairly dry January: dry February.	Dry January and February. Very dry March.	Good rainfall distribution December-April: poor cotton yields: American bollworm attack.	Dry December, otherwise good rainfall distribution.	A very wet year: a slight dry spell late January.	A drought year: an especially poor December and January.	A dry late January into February: a drought in March.	A dry December into January.	Good rainfall distribution.	Good rainfall distribution.	

*Differences statistically significant. P = ·05.

Rain-holding basins

In 1951/52 and 1956/57, with fairly good cotton yields, there were no yield increases as a result of tie-ridging, the first was the wettest season on record and 1956/57 was a season of very good rainfall distribution. By contrast in 1946/47 a very wet season with a good rainfall distribution; there was an increase of 269 lb. seed cotton/acre, an increase of 46 per cent from tie-ridging, but only a very small bulrush millet increase. Low yields of bulrush millet in 1951/52 were due to bad damage by birds (*Quelea*).

Lubaga

Ridging and tie-ridging have been compared with flat cultivation on the two main soil types: the friable "Ibushi" and the cemented hard-pan "Ibambasi". The latter is fairly fertile if the roots can penetrate the hard-pan and it has been shown that tie-ridging allows good water penetration, softening the hard-pan and allowing full root development. On both these soil types the crop increases of cotton and sorghum from tie-ridging compared with flat cultivation are spectacular in most years, frequently the yield may be more than doubled (Table II).

Prentice (1) has recorded his cropping experiences at Lubaga until 1945/46, comparing flat cultivation with cropping on tied-ridges, growing mainly cotton and sorghum. The biggest percentage cotton increase in that period was in 1943/44, from a crop failure of 90 lb. seed cotton/acre on the flat to 350 lb./acre on tied ridges, nearly a quadrupling of the crop yield. In 1944/45 with cotton there was an increase from 610 lb./acre to 1,100 lb. seed cotton per acre, an 80 per cent increase. In 1938/39, 1942/43 and 1943/44 there were very large sorghum and maize increases as a result of planting on tied ridges.

In general there have been no consistent differences in yield between planting on 3 ft., 4 ft. and 5 ft. ridges. It is difficult to make the larger ridges on the friable "Ibushi", and with

TABLE II—LUBAGA. RIDGING AND TIE-RIDGING: YIELDS LB./ACRE. SEED COTTON AND GRAIN

SEASON—SOIL TYPE	Crop	Flat Cultivation	Ridged and Tied	Percentage Increase due to Tie-ridging
1947-48 "Ibambasi"	Cotton	950	1,470	54*
1948-49 "Ibambasi"	Cotton	305	406	33*
1949-50 "Ibambasi"	Cotton	110	338	207*
1950-51 "Ibambasi"	Cotton	305	406	33
1952-53 "Ibambasi"	Cotton	233	464	99*
1954-55 "Ibambasi"	Cotton	330	711	116*
1955-56 "Ibambasi"	Cotton	524	648	24
1956-57 "Ibambasi"	Cotton	280	562	100*
Mean		379	625	65
1947-48 "Ibambasi"	Sorghum	1,370	2,600	90*
1948-49 "Ibambasi"	Sorghum	137	362	164*
1951-52 "Ibambasi"	Sorghum	190	469	147*
1952-53 "Ibambasi"	Sorghum	911	2,154	136*
1954-55 "Ibambasi"	Sorghum	1,021	1,145	11
1955-56 "Ibambasi"	Sorghum	315	799	154*
1956-57 "Ibambasi"	Sorghum	389	570	47*
Mean		619	1,157	87
1949-50 "Ibambasi"	Bulrush Millet	363	826	128*
1951-52 "Ibushi"	Cotton	947	997	5
1953-54 "Ibushi"	Cotton	491	915	86*
1954-55 "Ibushi"	Cotton	695	757	9
1954-55 "Ibushi"	Cotton	473	757	60*
1954-55 "Ibushi"	Cotton	266	660	148*
1955-56 "Ibushi"	Cotton	476	570	20*
Mean		558	776	39
1947-48 "Ibushi"	Maize	2,020	2,223	15
1947-48 "Ibushi"	Ground nuts (unshelled)	1,000	1,590	59*
1949-50 "Ibushi"	Sorghum	137	362	164*
1952-53 "Ibushi"	Sorghum	647	1,210	87*
1954-55 "Ibushi"	Sorghum	788	1,127	43*
1955-56 "Ibushi"	Sorghum	726	885	22
Mean		574	896	57

*Differences statistically significant. $P = \cdot 05$.

one exception the results given in Table II are from 3 ft. ridges. Comparisons here cover the 1947/48 to 1956/57 seasons. There have been occasions when no increases were recorded, for instance 1950/51, a season of good rainfall, and 1951/52, the wettest season on record. The largest cotton increase in this table was in 1947/48, an increase of 520 lb. seed cotton/acre; the largest percentage cotton increase in this table was in 1949/50, a trebling of the yield, the overall yield level being very low.

"Mbuga" Treatments

The Ukiriguru Valley bottom sandy clay soil "Mbuga", has a gentle slope, but when harrowed for planting, heavy storms can cause sheet erosion before the soil consolidates. Little agronomic work has been done on "Mbuga" soils but it would appear that the less this heavy soil is worked the better. Light hoeing has given better yields of grain than ploughing. In 1949/50 cotton and sorghum planted on the flat gave better yields and better growth than when grown on 3 ft. ridges not tied. In three experiments the comparative yields for sorghum were: flat, 707 lb. grain/acre, ridged, 475 lb.; flat, 1,165 lb., ridged, 780 lb.; flat, 1,135 lb., ridged, 850 lb.; all the differences were statistically significant.

Copied from work at Kongwa, broad-based ridges, 20 ft. or so wide, were made by tractor across the slope of the "Mbuga" to prevent sheet wash. Certainly as far as cotton was concerned they were not a success. In a wet season plants at the top of the broad ridges grew well and the rows approaching the furrows were waterlogged—in a dry season the reverse was the case; plants near the furrows got more moisture, while the rows on top of the ridge dried out.

Weeds and the Timing of Weeding—Ukiriguru

An attempt was made to reduce the hand labour needed in preparing the ridges for planting. Old ridges were renovated instead of making new ridges over last year's furrows, but weeds proved very troublesome when this was done. Possibly, one of the reasons for the African adopting the system ridge making was the early season control of weeds since the previous season's weeds are buried about 6 in. under the new ridge.

In one experiment cotton grown on renovated ridges yielded 595 lb. seed cotton/acre, compared with 1,058 lb. seed cotton/acre, grown on normally prepared ridges, a reduction of 46 per cent. Where compost at five tons/acre was incorporated under the surface of the old and new ridges, the seed cotton yields were 833 lb./acre for the old ridges and 1,350 lb./acre for the new ridges, a reduction of 38 per cent.

In 1949/50 a trial was planted on the hill sands to demonstrate the effects of delayed weeding, but due to attacks by American bollworm, jassid and bacterial blight the yields were exceptionally low and the results less striking. Cotton in which weeding was started in mid-January and given three weedings yielded 260 lb. seed cotton/acre which dropped to 178 lb. when the first weeding was omitted. When the first two weedings were omitted this yield became 75 lb./acre, all differences being statistically significant.

On the "Mbuga" during the same season, Dobb's sorghum, weeded at the end of December and again in late February, yielded 2,250 lb. grain/acre. Weeding twice, but delaying the start of weeding until early February, reduced the yield to 1,225 lb. grain/acre. The differences were again highly significant.

In 1950/51 the time-of-weeding trial was not planted to cotton until mid-January. Plots weeded early and then kept clean yielded over 900 lb. seed cotton/acre. Plots in which weed growth was allowed to develop after a first early weeding yielded only about 100 lb./acre. Plots where there had been a marked delay in starting the first weeding also had yields at this level.

It has been remarked that *Tridax repens* is the worst weed on the hill sand soils and that an early development of this weed, if allowed to occur, can greatly reduce yields. The first cotton indicator crop taken after a three-year "tumbledown" fallow rest in Trial 6 showed a depression of 70 lb./acre seed cotton compared with the control yield. In the following season the same treatment gave an increase of 350 lb./acre when the *Tridax repens* was weeded out early.

Time of Planting—Cotton

Appreciable delay in cotton planting is one of the greatest factors in reducing yields. With the seed stocks at present grown, land preparation in November and cotton planting through December are recommended. In some seasons planting in November gives slightly better yields, but November planting is difficult for the cultivators, and with heavy rain in the latter half of April extending well into May, the grade of cotton opening then is lowered by rain damage.

Table 3 shows the trend of decrease in yield due to delaying the planting dates of cotton.

At Ukiriguru in 1952/53 the latest planting was delayed by lack of rain until early in March, with the subsequent loss of all but a small proportion of the crop. However, planting as late as this is by no means uncommon amongst the cultivators.

For a number of years, non-replicated observation plots have been planted out in the surrounding districts and a summary of these is shown in the second half of Table 3. It is impossible to give an exact date to each time of planting as due to the scatter of the plots in the Province the dates of planting vary considerably. Early planting may be any time up to the first week of January with subsequent dates at three to four weeks intervals. The trend of declining yields is the same as at Ukiriguru but not quite so marked, as the spread of planting dates within each group to some extent obscures the effect.

Table III—Ukiriguru. Time of Planting: Yields lb./acre Seed Cotton

Season				
1952-53	Early December 2,062	Early January 1,690	Early March 425	
1953-54	Mid-December 1,200	Mid-January 1,037	Early February 400	
1955-56	Late November 812	Mid-December 587	Mid-January 438	Mid-February 313
1957-58	Mid-November 911	Mid-December 823	Mid-January 683	Mid-February 612

District Observation Plots:

Season	Number of Plots	Early Planted	Delayed	Late
1955-56	12	998	853	662
1956-57	13	1,273	1,067	891
1957-58	11	1,056	893	792
Mean		1,109	937	781

Summary

The customary practice at Ukiriguru of tie-ridging gave increases in yield with cotton and grain crops whilst controlling erosion adequately, the mean increases being 151 lb./acre seed cotton and 95 lb./acre millet grain. On the black loam and hard-pan soils of the south, large increases in yield from tie-ridging resulted.

It has been shown that delay in carrying out the first weeding of cotton will cause decreased yields and that the practice of re-making the ridges each season and burying the weeds below gives a good control of annual weeds such as *Tridax repens.*

Timely planting of cotton is probably the most important aspect which will lead to increased yields. With planting after early January the decline in yield is rapid and a full crop can never be attained.

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REVIEWS

Crop Production and Environment, by R. O. Whyte, published by Faber and Faber Ltd., London, England, 1960, pp. 392, plates 31, and figures 58. Price £3 3*s*.

This book is largely concerned with applied plant physiology. A list of some of the chapter headings indicates its scope: Biological Organization, Competition for Light, Synthetic Regulatory Substances, Gibberellin, Chemical Retardation of Growth and Flowering and so on.

It is an excellent survey of recent research and should be in the libraries of all agricultural stations and in the personal libraries of most agronomists. It will be a useful reference book for agronomists, horticulturists and plant phsiologists for many years. It is not often that one refers to a book at three guineas as cheap: this one is.

Beekeeping in the Tropics by Francis G. Smith, published by Longmans, London, 1960, 265 pp., 69 illustrations, price 45*s*.

This volume (one of a series of publications on Tropical Agriculture) deals specifically with every stage of bee farming, both large and small, under tropical conditions. The book is well thought out and provides instruction for the amateur beekeeper as well as advice to the professional. It makes interesting reading and considering the very few books available on the subject for *tropical* conditions, it should be in demand.

The price of 45*s*. seems rather high, but in view of the information it contains, it is well worth it.

C.A.M.

A STATISTICAL DESIGN FOR A PIG FEEDING TRIAL

By R. T. Clarke, Scott Agricultural Laboratories, Nairobi Kenya

(*Received for publication on 22nd June, 1960*)

The versatility of the latin square has long been appreciated by experimental workers in many fields, perhaps particularly in bioassay and experiments on livestock, and the literature abounds with examples where ingenuity has been used to remove variation from different sources. For example, it has been frequently used to remove genetic differences between lactating animals and also the effect of applying treatments at different periods within a lactation.

Recently, the latin square was found to be of use in an investigation into the effects of feeding supplements to pigs where experimental facilities were limited. In many countries, the practice of having all treatments replicated within a pen has been adopted, but in the case of a feeding trial this means that either pigs must be fed individually in their pens or else removed at feeding time and fed with other animals on the same treatment. This system, however, demands the initial expense of installing individual feeders for each animal, and may be unrealistic in the sense that such a procedure would never be adopted in practice and may remove the natural competition between feeders, thus giving an untrue picture. The alternative of having all pigs in a pen on the same treatment is invalid unless the treatment is replicated on other whole pens, when the experiment uses a prohibitively large number of experimental animals.

In the experiment to be described, it was desired to test four treatments, denoted symbolically by—

(*l*)—a control, where no supplement was fed.

a—normal rations with an antibiotic added.

c—normal rations with copper added.

ac—normal rations with both copper and antibiotic added.

Only four pens were available for the experiment, and these were not equipped with individual feeders. This meant that replication of each treatment in every pen was impossible, but the alternative of having all pigs in a pen on the same treatment is unacceptable because any observed difference between treatments may then be simply an unsuspected effect of pens, or a combination of the two. As a partial solution to this dilemma, it was proposed to adopt the procedure of having all animals in a pen on the same treatment and moving them from pen to pen at regular intervals as a means of balancing out pen differences. Diagrammatically:—

	Pen			
	1	2	3	4
Period I ..	(*l*)	*a*	*c*	*ac*
II ..	*a*	(*l*)	*ac*	*c*
III ..	*c*	*ac*	(*l*)	*a*
IV ..	*ac*	*c*	*a*	(*l*)

Four litters were available, and assuming litters of at least eight, two pigs from each litter are put on each treatment, so that litter differences are also balanced out. If it is further possible to choose four pigs of each sex from each litter, then by putting one of each sex from each litter on every treatment, both sex and litter differences are removed.

The situation is now as follows. Each of the pens contains eight pigs, all on the same treatment. The eight consist of four pairs, one pair from each litter, and if possible one of either sex. The period of duration of the experiment is divided into four, and (if it is impossible to have one of either sex, sex differences can be removed by a covariance analysis as a dummy variate) for the first period, the eight which are fed, say, copper, are in Pen 3. At the end of the first period, these eight, still on the same ration, are moved to Pen 4, and so on, and similarly for the animals on every treatment. At the end of the duration of the experiment, each animal has spent an equal amount of time in each pen. It is assumed that there is no interaction between pen conditions and pig age; this may well be untrue, since if the conditions in one pen are unfavourable their effect will be greater on a young pig than on a more mature one, but it is a more reasonable assumption than that there are no pen differences at all.

If the observations taken are the live weight gain on each animal over each period, the design is a simple 4 x 4 latin square with eight observations at each place in the square. The analysis of variance is then:—

Rows	3 df.	
Columns	3	
Treatments	3	
Error	6	
Residual	112	= between individuals within pens and within periods.
Total	127	

The sums of squares for rows, columns, treatments and error are found in the usual manner, by adding up eight observations within each "cell" of the square, and doing an analysis of variance on these sums. The residual sums of squares is the total of the 16 separate sums of squares within each cell of the latin square; there will be seven degrees of freedom between the eight observations, giving a total of 7 x 16 = 112. This residual variation consists of three components—variation between litter pairs, variation between sexes within litter pairs, and interaction between sex and litter. The treatment sums of squares, which are of main interest, can be split into three components in order to determine the effects of copper, antibiotic and interaction between the two, and the mean squares for these single degrees of freedom can be tested against the error mean square.

If the only observations taken are the overall conversion ratio of each set of animals in each period, the analysis is simpler, since there is now only one observation in each cell, and the analysis is that of the familiar 4 x 4 latin square. It may be possible to divide the time duration of the experiment further into, say, a porker period and a baconer period. If these are, say, eight-week and 12-week periods, weekly moving of pigs would give two replications of the latin square for the porker period and three for the baconer period, provided that the frequency of movement did not affect the treatments. It would then be possible to determine any interaction of treatment with the two main periods: that is, whether the effect of treatments are different in the two (porker and baconer) periods.

SUMMARY

An experimental procedure is given for a supplement feeding trial on pigs, where individual feeding was impossible, and where only four pens and four litters were available to test four treatments. The procedure assumes that there is no interaction of pen effect with pig age, but this is held to be more reasonable than the assumption that there are no pen differences at all.

REVIEW

AN INTRODUCTION TO BACTERIAL PHYSIOLOGY, 2nd. Ed., by E. L. Oginsky and W. W. Umbreit, published by W. H. Freeman and Co., San Francisco, 1959, pp. 443, price 7/50.

The advances made in bacterial physiology during the past five years have called for some revision of the first edition of this excellent book. The fundamental concepts established in the first edition, however, still hold, and the new material has been satisfactorily integrated with these.

Primarily a textbook for undergraduates, it is designed to bridge the gap between general bacteriology and graduate studies in bacterial physiology. The text is divided into six sections, each prefaced with a very pertinent and stimulating introduction. The six sections, which are further subdivided into chapters (with references at the end of each) deal with the nature of bacterial physiology, bacterial anatomy, populations, metabolism (the longest of the sections), variations on a theme (which deals with extremes encountered among bacteria) and the capacity of the cell, including its adaptation and mechanism of survival. The accompanying photographs and illustrations are first class.

In addition to its value to the student, this book will also be useful to research workers who are themselves not bacteriologists but need to know something of bacterial processes, for example a chemist working on organic matter transformations in soil. It can, in fact, be profitably used by workers in many fields on which bacteriology impinges.

This book is both readable and stimulating. It not only provides information but arouses one's interest by the provocative way in which parts of the text are presented, and by pointing out the problems involved in this fascinating subject.

H. F. B.

THE CULTURE OF CARP (Cyprinus carpio L.) IN PONDS IN UGANDA

I—PRELIMINARY OBSERVATIONS ON GROWTH AND REPRODUCTION

By A. G. Wurtz, Inland Fisheries Biologist, F.A.O., and C. J. H. Simpson, Fishery Officer, Game and Fisheries Department, Uganda

(*Received for publication on 23rd June, 1960*)

The use of *Tilapia* as a culture fish throughout East and Central Africa is well known (Chimits 1955, 1957; De Bont *et al.* 1948; De Bont 1949, 1952). *Tilapia* have been extensively cultured in fish ponds at the experimental fish farm at Kajansi, near Kampala, since 1953. Monocultures of *Tilapia* present difficulties in management owing to their specialized food habits. *Tilapia* reach maturity in fish ponds at the age of between three to six months. Thereafter their growth rate slows appreciably and the reproductive cycle becomes rapid and continuous; this leads to overpopulation in the ponds. Various ways of overcoming these disadvantages have been suggested. They include monosex culture (De Bont and Hers 1950, Brown and Van Someren 1953; Van Someren and Whitehead 1959) and the introduction of predatory fish into the ponds (work in progress at Kajansi). It will take time to evaluate the results and to design suitable techniques of management that can be adopted by African peasant farmers. The problem of finding a pond fish to supplement the *Tilapia* under Uganda conditions is urgent, due to the fact that over 5,000 fish ponds have been built by Africans in the last few years.

It was therefore decided to test the suitability of the Mirror Carp as a culture fish under East African conditions, as they are known in Europe and the Middle East to utilize fully the food resources of ponds (Wurtz 1960). Carp readily eat zooplankton, bottom fauna, detritus, soft higher plants and epiphytic algae; they are also known to have a good response to artificial feeding. Cotton seed cake, ground nut cake, maize and other cereals have been commonly used. Due to the wide range of foods that carp commonly consume, most methods of fertilization will give higher yields of fish (Wunder 1938; Mortimer and Hickling 1954). The warmer southern European countries obtain higher yields of carp than do the colder northern countries so that carp could be expected to give high yields in the tropics. Carp had previously been used as culture fish in the Belgian Congo (De Bont and Hulot 1950) and were reported to give lower yields than *Tilapia* and to depress the yield of *Tilapia* when the fish were stocked together.

Two small stocks of *C. carpio* L. were obtained as a free gift from the Nir-David Fisheries Station, Israel. They were flown in plastic bags from Tel Aviv to Entebbe via Rome. They were in transit for 24 hours without any casualties.

GROWTH

The first group of carp was obtained in December, 1957, when the fish had a mean total length of 18 cm. and were six months old. They were stocked in a small pond which had previously been fertilized with a mixture of sulphate of ammonia and superphosphate in the ratio 5:3. The fish were fed daily with a mixture of cotton seed cake and ground nut cake. The food was placed on a wire tray which was submerged in the same corner of the pond at the same time each day. The carp rapidly learnt to take the food from the tray. Any food that was not consumed was removed from the pond. The heavy applications of inorganic fertilizer were discontinued as they caused an excessive development of algae with the consequent danger of oxygen depletion in the early mornings. The carp were transferred to a larger pond in April, 1958, and have remained there to date. Table I and Figure 1 show the growth and the weight increase of the carp from the 6th month to the 34th month.

The general shape of the growth curve is that shown by most fish, being steep in the early months and having a marked flexure after the 20th month of growth. In their 20th month the mean length of the carp was 48.5 cm.; by the 32nd month the mean length was 55.4 cm. so that 88 per cent of the growth had been completed by the 20th month. Although there was no increase in length during the final months of the observations there was no slowing of the weight gain. The carp continued to gain weight regularly throughout the whole period of the observations, and by the 34th month had reached an average weight of 2,860 gm. The heaviest fish had, however, reached 4,750 gm.

The shaded portion of the growth curve shows the length of the fastest growing and the slowest growing fish. The variation in the growth rate is least in the early months and most in the later months when it was 10 per cent above or below the mean.

Table I and Figure 2 show the mean monthly increments in length and weight of the first group of carp. The greatest length increment, of 5.0 cm., was in April, 1958, the date when the carp were moved from a small to a large pond.

The second group of carp was obtained from Israel in November, 1958, when they were three months old. Their total length varied from 8.5 cm. to 11.5 cm. They were stocked and fed under the same conditions as the first group. Table II and Figure 3 show the growth and weight increases from the 4th to the 21st month. The curve is steep in the early months of growth and again shows a cessation of growth at the 19th month, whereas the weight of the fish continued to increase. At the 21st month the mean total length of the fish was 47.2 cm. and the mean weight was 1,500 gm., but the largest fish was 55.0 cm. in length and weighed 2,500 gm. The variance of the mean length increments is least in the early months of growth and most in the later months. The lengths recorded show a variation of 14 per cent around the mean. Figure 4 shows the mean monthly increments in length and weight of the second group of carp. There is a regular decrease in the monthly length gain. The growth varies from 5.2 cm. per month in the 5th month to nothing after the 19th month.

TABLE I

Date	Age	Interval between observations	Mean length	Mean length increment per month	Mean weight	Mean weight increment per month
	months	*months*	*cm.*	*cm.*	*gm.*	*gm.*
December, 1957	6	—	18·0	—	90	—
March, 1958 ..	9	3	22·2	1·4	160	23
April	10	1	27·2	5·0	290	130
July	13	3	37·2	3·3	555	88
October ..	16	3	40·0	0·9	800	82
November ..	17	1	42·1	2·1	950	150
December ..	18	1	44·0	1·9	1,050	100
January, 1959 ..	19	1	46·3	2·3	1,250	200
February ..	20	1	48·5	2·2	1,500	250
April	22	2	50·1	0·8	1,750	125
May	23	1	51·0	0·9	1,850	100
August ..	26	3	53·6	0·9	2,000	50
February, 1960	32	6	55·4	0·3	2,600	100
April	34	2	55·2	—	2,860	130

TABLE II

Date	Age	Interval between observations	Mean length	Mean length increment per month	Mean weight	Mean weight increment per month
	months	*months*	*cm.*	*cm.*	*gm.*	*gm.*
1st Nov., 1958	4	—	10·0	—	25	—
24th November	4¾	¾	14·7	4·7	45	20
December ..	5	1	19·9	5·2	130	85
January, 1959 ..	6	1	24·5	4·6	220	90
February ..	7	1	27·1	2·6	280	60
March ..	8	1	29·7	2·6	350	70
April	9	1	32·1	2·4	420	70
May	10	1	33·7	1·6	505	85
June	11	1	35·7	2·0	580	75
February, 1960	19	8	47·6	1·4	1,150	71
April	21	2	47·2	—	1,500	175

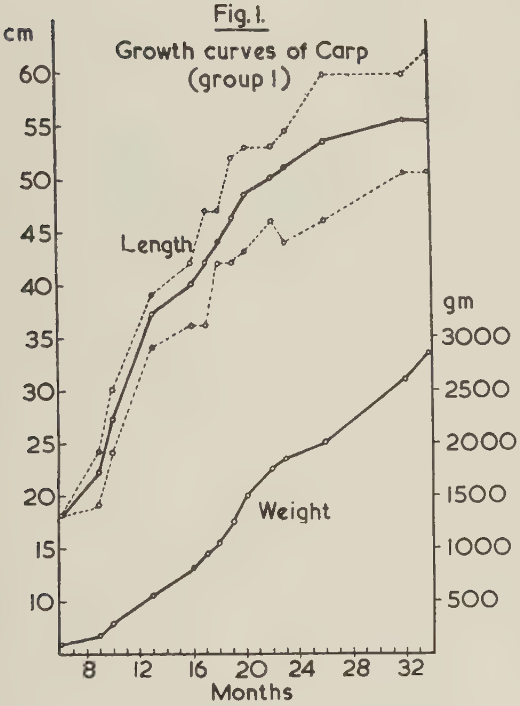

Fig. 1.

Growth curves of Carp (group 1)

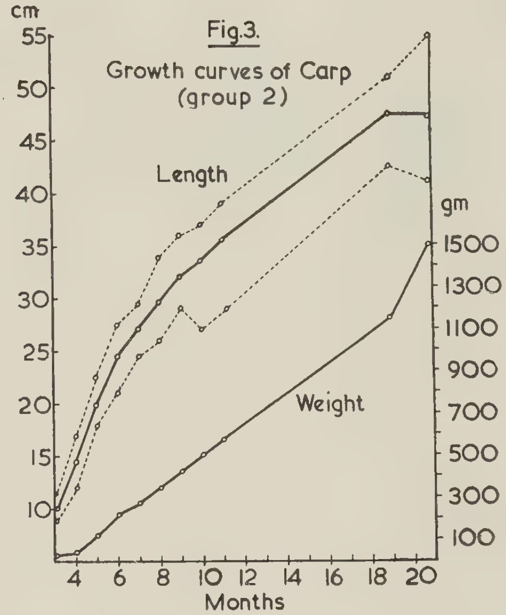

Fig. 3.

Growth curves of Carp (group 2)

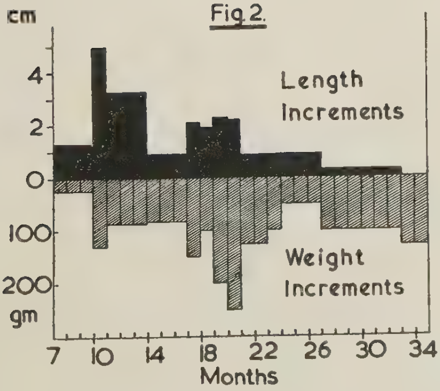

Fig. 2.

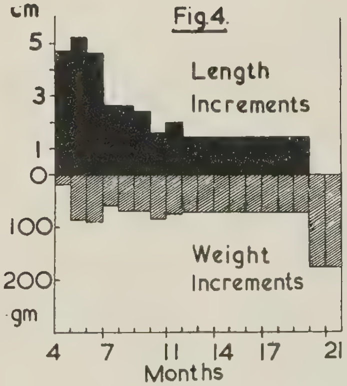

Fig. 4.

Fig.5.

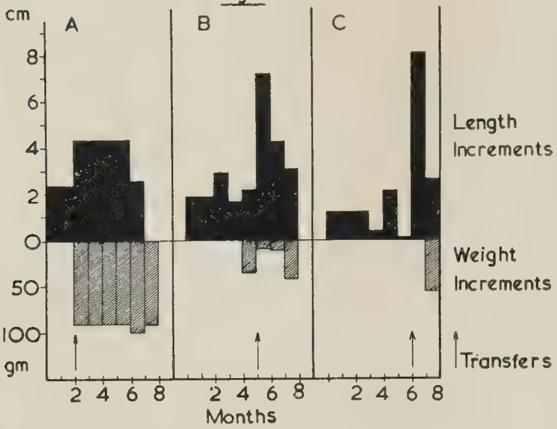

Fig.6

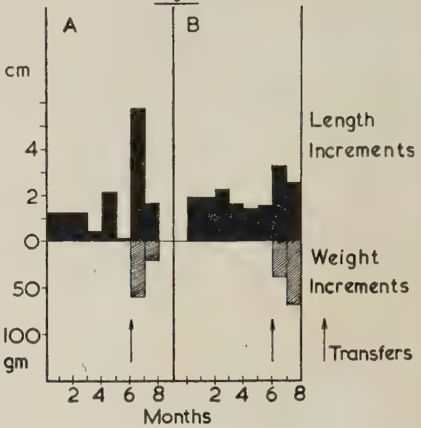

TABLE III

Date	Figure	Age	Interval between observations	Mean length	Mean length increment per month	Mean weight	Mean weight increment per month
		months	*months*	*cm.*	*cm.*	*gm.*	*gm.*
August, 1959 . .	5*a*	Spawned	—	0·5	—	—	—
October . .		2	2	5·3	⟶ 2·4	4	—
February, 1960		6	4	22·8	4·4	372	92
March . .		7	1	25·4	2·6	471	99
April		8	1	25·4	—	564	93
August, 1959 . .	5*b*	Spawned	—	0·5	—	—	—
October . .		2	2	4·3	1·9	—	—
November . .		3	1	7·2	2·9	—	—
December . .		4	1	8·9	1·7	18	—
January, 1960		5	1	11·1	2·2	52	35
February . .		6	1	18·3	⟶ 7·2	72	19
March . .		7	1	22·6	4·3	93	21
April		8	1	25·7	3·1	136	43
August, 1959 . .	5*c*	Spawned	—	0·5	—	—	—
November . .		3	3	4·1	1·2	—	—
December . .		4	1	4·5	0·4	—	—
January, 1960		5	1	6·6	2·1	—	—
February . .		6	1	6·7	0·1	—	—
March . .		7	1	14·8	⟶ 8·1	141	—
April		8	1	17·4	2·6	197	56
August, 1959 . .	6*a*	Spawned	—	0·5	—	—	—
November . .		3	3	4·1	1·2	—	—
December . .		4	1	4·5	0·4	—	—
January, 1960		5	1	6·6	2·1	—	—
February . .		6	1	6·7	0·1	20	—
March . .		7	1	12·4	⟶ 5·7	80	60
April		8	1	14·0	1·6	101	21
August, 1959 . .	6*b*	Spawned	—	0·5	—	—	—
October . .		2	2	4·3	1·9	—	—
November . .		3	1	6·5	2·2	—	—
December . .		4	1	8·1	1·6	—	—
January, 1960		5	1	9·5	1·4	—	—
February . .		6	1	11·0	1·5	70	—
March . .		7	1	14·2	⟶ 3·2	109	39
April		8	1	16·7	2·5	176	67

⟶ Transfer of fish to growing ponds.

REPRODUCTION

The first attempts made to spawn the carp did not prove successful. It was attempted to induce them to spawn in the pond that they had occupied during the previous 16 months. Various artificial substrates were made in the pond that were thought would be suitable for the deposition of carp eggs. These included gravel, sand and bundles of conifer branches that were held on the bottom of the pond with weights. In August, 1959, it was decided that European practice should be followed and the carp placed in spawning ponds, each pond containing two males and one female. When the breeding carp were moved to their new ponds, spawining took place within 24 hours. At the time of spawning the first group of carp were 26 months old, and the second group of carp were 13 months old. The gonads of the fish of the first group were ripe before the first spawning took place.

A second spawning took place in February, 1960. The second group of carp were observed, by palpation, to have ripe gonads and four males and two females were stocked in a small pond. Spawning took place within 24 hours. During the August and February spawning it was found that the Nile Cabbage (*Pistia stratiotes* L.) was an excellent substrate on which the carp could attach their eggs. Each root and rootlet when in the water is widely spread and the eggs, which are sticky, are held clear of each other and are well aerated.

At the time of the August, 1959, spawning, the Group 1 fish measured 53.6 cm. total length and weighed 2,000 gm. At the February spawning the Group 2 fish measured 47.6 cm. and weighed 1,150 gm.

The August spawning produced 3,913 fingerlings and February spawning 593 fingerlings. The number of eggs laid and their subsequent mortality was not recorded.

In Europe carp lay up to 500,000 eggs at a time and it is usual to rear 5,000 of these to fingerling size.

A *Dubisch* type spawning pond was also tried (Schäperclaus 1949). This pond has a raised platform in the centre surrounded by a ditch. The platform is planted with grass which is mowed to form a close sward. When the pond is filled the platform is covered with water to a depth varying from 18 in. to 6 in. Two male and one female carp are introduced. The sward is said to make a suitable substrate for the eggs. The rubbing action of the short grass on the abdomen of the female is said to stimulate her to release her eggs, which become attached to the grass. When the spawning is completed the water level is lowered, forcing the adult fish to return to the drainage ditch where they are easily recovered and removed. The pond is then refilled and the platform reflooded, so that the development of the eggs can proceed. At Kajansi this technique is not successful owing to the rapid rotting of the grass on the platform. The pond rapidly becomes deoxygenated and toxic substances are formed which kill the eggs.

GROWTH AFTER SPAWNING

The first group of fry, spawned in August, 1959, had grown to 4.1 cm. standard length by the second month. After the second month the growth became very slow, reaching 6.6 cm. standard length in January, 1960, five months later. The poor growth rate was due to overcrowding and a marked improvement was noted as soon as the fish were transferred to their growing ponds. The need to transfer carp from spawning to growing ponds is well documented in the European literature (Schäperclaus 1949). Table III and Figures 5 and 6 show the mean monthly length increments for the fish spawned in August, 1959, and then transferred to growing ponds. Figure 5A shows the performance of the fingerlings transferred at two months of age to a four-acre pond. Four months after transfer when the fish were six months old they had reached a mean length of 22.8 cm. and a mean weight of 372 gm. Thereafter the growth slowed and appeared to have stopped after the 7th month. Although no further increase in length was observed after the 7th month, further increases in weight had occurred by the 8th month. The mean weight of the carp was 564 gm. The weight gain of the fish spawned at Kajansi is greater than that of the original stock. The first group of carp from Israel were six months old on arrival at Kajansi and had only reached 150 gm. by the 8th month, while the second group which was three months old on arrival had reached 350 gm. by the 8th month.

Figure 5B shows the large mean length increment per month of 7.2 cm. that can be obtained after transfer of the fingerlings from their spawning pond to a growing pond. A mean length increment of 7.2 cm. in the 6th month is most interesting considering that they had been overcrowded and stunted for the previous five months. This ability of the carp to restart growth when moved to a favourable environment is of the greatest interest to the fish farmer.

Figure 5C shows the greatest mean length increment per month obtained when the carp were transferred from their high density spawning pond to a low density growing pond. These carp on transfer attained a mean monthly increment of 8.1 cm. during their 7th month.

Figures 6A and 6B show the least mean increments in length after transfer, being 5.7 cm. and 3.2 cm. respectively.

WATER TEMPERATURES

Mean water temperatures in the ponds at Kajansi vary from 22° C. to 28° C. The absolute maximum temperature reached during the period of these observations was 36° C. and the absolute minimum temperature recorded was 15° C. The largest temperature variation in any one period of 24 hours was 12° C.

SUMMARY

Carp grow well and gain weight rapidly under Uganda conditions. The original stock reached 1,500 gm. in 20 months. The largest carp at Kajansi had grown to 4,750 gm. in 34 months. They are capable of increasing in weight when they have ceased to grow in length.

Carp which have been overpopulated and stunted can start to grow rapidly when they are transferred to less crowded ponds. They are then capable of growing at the rate of between 3.2 cm. and 8.1 cm. per month.

Controlled spawning of carp is possible by pairing the fish in spawning ponds when the fish are ripe. The Nile Cabbage (*Pistia stratiotes* L.) is a suitable substrate for carp eggs. The fry can be reared to fingerling size without excessive mortality.

Carp can tolerate temperatures between 15° C. and 36° C. in fish ponds in Uganda.

The conclusions of De Bont (De Bont and Hulot 1950) on the low yield of carp in pond culture in Central Africa have not been substantiated.

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REVIEW

WINTER KEEP ON THE FARM by Ian Moore, published by Farmer and Stock Breeder Publications Ltd., London, 1960, pp. 86, price 9*s*. 6*d*.

In this handbook, a companion volume to *Silage and Haymaking* and by the same author, 47 of its 86 pages are devoted to the production of kale as a fodder crop. Starting with an appraisal of its value the author then deals with problems of variety selection, manuring, growing and utilization and backs up the case in favour of kale with a chapter on the economics of its production.

On his own admission Dr. Moore recognized that other fodder crops exist and has "To ensure placing the crop in proper perspective" included ten pages on cabbages, leafy succulents and fodder root crops. This easily read book is rounded off by brief reference to weeds, pests and diseases. Tables giving a comparison of feeding values and production costs of fodder crops are provided.

To those not farming in the United Kingdom the main value of the book is in the attention it focuses on the value of these crops for supplementary feeding, the chapter of most general interest being that dealing with the efficient utilization, by electric fencing, etc., of the feed provided.

T.L.

A TABLE OF ESTIMATES OF NUTRITIVE VALUES OF RUMINANT FEEDS

By J. Glover, East African Agriculture and Forestry Research Organization, Kikuyu, Kenya, D. W. Duthie, Bristol College of Science and Technology, England, and H. W. Dougall, Grassland Research Station, Kitale, Kenya

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In Europe and America knowledge of the nutritive value of animal feeds has been accumulating gradually for the past century or more and it is therefore an easy matter for the modern farmer in those regions to consult a reference book for information on any normal feed. This is not possible in East Africa for apart from the pioneer work of French [1], Todd [2] and Rogerson [3] there is no information about our local feeding stuffs. Moreover it is no consolation for the local farmer to know that by the conventional processes he will be obliged to wait for several decades before the results of time-consuming and costly digestibility trials become available. Attention was drawn to this unfortunate situation in 1949 when the following recommendation was put forward at a Specialist Conference in Agriculture, Plant and Animal Nutrition held in Australia [4], ". . . that research should be intensified aiming at a method or methods of feed description from which useful estimates of their digestible energy and protein contents may be made without the necessity for actual digestion trials of specific samples of feedstuffs".

TABLE I—ESTIMATES OF DCP AND TDN AT DIFFERENT LEVELS OF CP AND CF

%CF	5%		10%		15%		20%		25%		30%		35%		40%		45%	
%CP	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN
2	0·4	74	0·4	67	0·4	58	0·3	51	0·3	45	0·3	38	0·2	32	0·2	27	0·2	21
3	1·0	84	0·9	77	0·9	71	0·8	64	0·8	58	0·7	53	0·7	47	0·6	42	0·6	37
4	1·6	86	1·5	79	1·4	73	1·4	68	1·3	62	1·2	57	1·2	53	1·1	48	1·0	43
5	2·3	85	2·2	79	2·1	74	2·0	68	1·9	63	1·9	59	1·8	54	1·7	50	1·6	46
6	3·0	84	2·9	78	2·8	73	2·7	68	2·6	63	2·5	59	2·4	55	2·3	51	2·2	47
7	3·8	82	3·7	77	3·6	72	3·4	68	3·3	63	3·2	59	3·1	55	3·0	51	2·9	46
8	4·6	81	4·5	76	4·3	72	4·2	67	4·1	63	3·9	59	3·8	55	3·7	51	3·5	48
9	5·5	80	5·3	75	5·1	70	5·0	66	4·9	62	4·7	58	4·6	55	4·4	51	4·3	48
10	6·3	78	6·2	74	6·0	70	5·8	65	5·7	62	5·5	58	5·3	54	5·2	51	5·0	48
11	7·2	77	7·1	73	6·9	69	6·7	65	6·5	61	6·3	58	6·1	55	6·0	51	5·8	49
12	8·2	76	8·0	73	7·8	68	7·6	64	7·4	61	7·2	57	7·0	54	6·8	51	6·6	48
13	9·1	76	8·9	71	8·7	68	8·5	64	8·3	60	8·1	57	7·8	54	7·6	51	7·4	48
14	10·1	75	9·9	71	9·6	67	9·4	64	9·2	61	8·9	57	8·7	54	8·5	51	8·2	49
15	11·1	74	10·8	70	10·6	68	10·3	64	10·1	61	9·9	57	9·6	55	9·4	51	9·1	49
16	12·1	74	11·8	71	11·6	67	11·3	63	11·0	61	10·8	57	10·5	54	10·2	51	10·0	49
17	13·1	73	12·8	71	12·6	67	12·3	64	12·0	60	11·7	57	11·4	55	11·2	51	10·9	49
18	14·1	74	13·9	71	13·6	66	13·3	64	13·0	61	12·7	57	12·4	54	12·1	52	11·8	49
19	15·2	73	14·9	70	14·6	67	14·3	64	14·0	60	13·7	57	13·3	55	13·0	52	12·7	50
20	16·3	73	16·0	70	15·6	67	15·3	64	15·0	61	14·6	58	14·3	56	14·0	53	13·6	50
21	17·4	73	17·0	70	16·7	67	16·3	64	16·0	61	15·6	58	15·3	55	14·9	54	14·6	51
22	18·4	74	18·1	71	17·7	67	17·3	64	17·0	61	16·6	58	16·2	55	15·9	54	15·5	51
23	19·6	74	19·2	71	18·8	68	18·4	64	18·0	61	17·7	58	17·3	57	16·9	54	16·5	51
24	20·7	74	20·3	71	19·9	68	19·5	64	19·1	62	18·7	59	18·3	57	17·9	54	17·5	52
25	21·8	74	21·4	71	21·0	69	20·6	66	20·2	62	19·7	59	19·3	58	18·9	55	18·5	52
26	22·9	76	22·5	72	22·1	69	21·6	65	21·2	63	20·8	60	20·3	57	19·9	56	19·5	53
27	24·1	75	23·7	73	23·2	70	22·8	66	22·3	64	21·9	61	21·4	58	21·0	57	20·5	53
28	25·2	76	24·8	72	24·3	70	23·8	67	23·4	63	22·9	62	22·4	58	22·0	57	21·5	54
29	26·4	77	25·9	73	25·5	71	25·0	67	24·5	64	24·0	62	23·6	59	23·1	58	22·6	54
30	27·6	77	27·1	73	26·6	72	26·1	68	25·6	66	25·1	63	24·6	59	24·1	58	23·6	56
35	33·6	81	32·9	76	32·6	75	31·9	71	31·3	68								
42	42·0	84	41·6	82	40·7	79	40·3	77										
45	45·0	86	45·0	84	45·0	83	43·9	79										

Our work during the past few years has been directed towards this end, for we have sought methods to obtain average estimates of the nutritive value of animal feeds without recourse to feeding experiments and our progress has been reported in a series of papers in the Journal of Agricultural Science [5].

We are now in a position to estimate the nutritive value of ruminant feeds in terms of their digestible crude protein (DCP) and total digestible nutrients (TDN) from knowledge of the crude protein (CP) and crude fibre (CF) content of their dry matter. The estimates of DCP and TDN corresponding to varying levels of crude protein and crude fibre are given in the accompanying Table I.

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REVIEW

Dairy Produce (No. 11), 1959, 134 pp., price 7*s.* 6*d.* Fruit (No. 10), 1959, 203 pp., price 10*s.* Meat (No. 11), 1959, 111 pp., price 7*s.* 6*d.* Obtainable from H.M. Stationery Office or from the Secretary, Commonwealth Economic Committee, 2 Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

These reviews present up-to-date summaries of production, international trade, and consumption, for groups of allied commodities, with special reference to the part played by Commonwealth countries. They include statistics up to 1958 and in some cases 1959.

The upward trend in milk production appears to have been checked in 1959, although production of dairy produce, with the exception of condensed milk, increased. Expansion in world butter production was wholly in the Commonwealth countries, but they played only a minor part in increase in world cheese production. As the Governments of most countries exercise some measure of control or support over prices, marketing and trade for milk and dairy produce these are analysed in detail in an appendix in the Dairy Produce review.

World production of fruit continued to rise, but trade in dried fruit and fruit juices declined. There was a rise in the world export of canned fruits, the United Kingdom being the main outlet for them, particularly from Commonwealth sources.

World production of meat rose, the Commonwealth countries sharing fully in the expansion in United States imports. There was a slight decline in world production of beef and veal in 1958 due mainly to a reduction in output in the United States, but the Commonwealth total increased. World production of mutton and lamb rose again, the Commonwealth countries accounting for a considerable part of the increase. World production of pig-meat also increased, the Commonwealth countries sharing fully in this expansion together with several European countries and the Soviet Union. World production of poultry meat has increased markedly in recent years as a result of rapid developments in the broiler industry. Various measures affecting the production, marketing and prices of meat in the main producing countries are described in an appendix which includes an analysis of the agricultural policies in the six Common Market countries as they affect meat.

AVERAGE NUTRITIVE VALUES OF KENYA FEEDING STUFFS FOR RUMINANTS

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Glover, *et al.* [1] give a table of average estimates of the percentage of digestible crude protein and total digestible nutrients to be expected from ruminant feeds ranging in crude protein content from 0-42 per cent and in crude fibre content from 5-45 per cent of the dry matter. It can be used for the computation of rations for dairy cows and other ruminants, according to the system of rationing recommended by Morrison [2], or Woodman [3], or according to Forbes' [4] concept of regarding rations as "wholes".

Average estimates of the apparent nutritive value of ruminant feeds actually grown in Kenya and analysed in this laboratory during the course of many years, have been obtained from this table. Descriptions of the feeds and estimates of their nutritive value expressed on a dry-matter basis, are given in the appended table: Ca and P were not determined in all feeds.

Definitions of the terms used in the table can be found in Morrison's book or Woodman's bulletin: gross digestible energy (GDE) is the energy contained in the total digestible nutrients.

Example

The rationing of a Jersey cow of 800 lb. bodyweight with an appetite of 22 lb. dry matter daily which at the present early stage of its lactation is giving 2½ gallons of milk daily with a butterfat content of 5 per cent.

According to Morrison, this animal's requirements are:—

	Digestible crude protein DCP	Total digestible nutrients TDN
For maintenance ..	0·51	6·1
For 2½ gal. of milk ..	1.32	9·0
Total ..	1·83	15·1

The only pasturage available to the animal is a somewhat stemmy Rhodes grass ley in its third year. It is seen from the tables that this grass at this stage of growth has the following composition and nutritive value on a dry matter basis:—

	Composition		Nutritive Value	
	Crude Protein CP	Crude Fibre CF	DCP	TDN
Rhodes grass, 14" high, some flowering heads	8·9	32·8	4·5	56
22 lb. of this grass contains			0·99	12·3

It is clear that this pasture cannot supply the digestible crude protein or the total digestible nutrients required by the Jersey, and in order that its requirements are met a wholly grass diet has to be restricted in favour of protein-rich and energy-rich supplements. Two feeds amongst many others with these respective properties are cottonseed cake and white maize meal, and it is seen from the tables that the composition and nutritive value of each of these feeds are as follows:—

	CP	CF	DCP	TDN
Cottonseed cake ..	37·5	18·4	35·0	74
Maize meal, white ..	8·6	1·9	5·2	82

According to a conventional system of rationing such as Morrison's, the Jersey's requirement could be met as follows:—

	DCP	TDN
10 lb. Rhodes grass contain ..	0·45	5·6
3 lb. cottonseed cake contain ..	1·05	2·2
9 lb. maize meal, white contain	0·47	7·4
22 lb. mixture contain	1·97	15·2

In this example, the Jersey's requirements for DCP and TDN are obtained by adding the separate amounts of DCP and TDN subscribed by each component of the ration.

However, if the ration is considered as "a whole", the following picture emerges:—

	CP	CF
10 lb. Rhodes grass contain ..	0·89	3·28
3 lb. cottonseed cake contain ..	1·13	0·55
9 lb. maize meal, white contain	0·77	0·17
22 lb. of the feed as "a whole" contain	2·79	4·00
100 lb. of the feed as "a whole" contain	12·7	18·0

From the table of Glover, *et al.* [1] it is seen that a feed containing 12.7 per cent CP and 18.0 per cent CF also contains 8.3 per cent DCP and 65.6 per cent TDN, so:—

	DCP	TDN
100 lb. of the feed as "a whole" contain	8·3	65·6
22lb. of the feed as "a whole" contain	1·83	14·4

By this system of rationing the animal's requirement for DCP is met, but not its requirement for energy (TDN). The shortfall of 0.7 lb. TDN should present no serious problem to this animal if it was well nurtured during pregnancy and had calved down with a good reserve of energy, for it could then meet this small energy deficit from its own resources by "milking from the back". If on the other hand the animal cannot depend on its own reserves to provide the additional energy required, the TDN deficit must be made good by further restricting the intake of fibrous grass of relatively low energy value in favour of the high-energy feed, and this must be done without upsetting the DCP requirement. It can be achieved by arranging the ration in the following proportions:—

	CP	CF
8 lb. Rhodes grass contain ..	0·71	2·62
3 lb. cottonseed cake contain ..	1·13	0·55
11 lb. maize meal, white contain	0·95	0·21
22 lb. of the feed as "a whole" contain	2·79	3·38
100 lb. of the feed as "a whole" contain	12·7	15·4

The crude protein content of the feed as "a whole" remains the same but its crude fibre content is greatly reduced and it can be seen from the Glover, *et al.* [1] table that whereas the amount of digestible crude protein remains substantially the same as before the amount of TDN that is now available has been markedly increased. Thus:—

	DCP	TDN
100 lb. of the feed as "a whole" contain	8·4	68·0
22 lb. of the feed as "a whole" contain	1·85	15·0

These amounts of DCP and TDN would enable this Jersey to obtain maintenance and supply 2½ gallons of milk containing 5 per cent butterfat.

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DESCRIPTION	Crude Protein	Digestible Crude Protein	Nutritive Ratio	Total Digestible Nutrients	Gross Digestible Energy	Crude Fibre	Ca	P
	CP	DCP	NR	TDN	GDE	CF		
FOR CATTLE SHEEP AND GOATS								
ROOTS—								
Fodder beet, Otofte Red	8·7	5·1	14·1	77	79	7·5		
Fodder beet, Hunsballe	9·5	5·8	12·3	77	79	7·5		
Fodder beet, Pajberg Rex	9·3	5·6	12·6	76	78	7·5		
Kohl rabi	17·5	13·4	4·3	71	76	10·0		
Mangold, Yellow Globe	12·4	8·4	7·8	74	77	7·5		
Mangold, Yellow Tankard	11·1	7·2	9·3	74	77	7·5		
Topine (*Helianthus tuberosa*)	8·8	5·3	14·0	80	82	5·4		
MISCELLANEOUS GREEN FOODS—								
Banana leaves	16·0	11·3	4·7	64	69	20·0	0·58	0·18
Canna leaves	13·1	8·7	6·6	66	69	18·0		
Niger oil, whole plant in full flower	9·2	4·8	10·8	57	59	31·9		
Rape	19·7	15·6	3·5	70	76	9·9	1·46	0·44
Russian comfrey, 5-8 inches high	17·3	13·0	4·3	69	74	12·6	1·56	0·47
Sunflowers, 10 inches high	27·2	23·9	2·0	72	82	9·4	0·55	0·28
Sunflowers, 13 inches high	25·8	22·0	2·1	68	77	13·4	1·65	0·27
Sunflowers, 26 inches high	26·8	23·1	2·0	69	78	13·2	1·71	0·32
Sunflowers, 44 inches high	27·7	24·3	1·9	70	80	12·1	1·79	0·27
Sweet potato tops	18·1	13·9	4·0	70	76	10·7	0·83	0·15
Thousand-headed kale	17·5	12·8	4·0	64	69	20·0		
BY-PRODUCTS—								
Coffee hullings	2·0	0·2	138·0	28	28	35·9		
Cottonseed husks	3·2	0·6	59·0	41	41	46·1	0·23	0·08
Maize cobs without grain	1·3	0·1	—	20	—	36·3		
Maize on the cob meal	5·5	2·2	26·3	58	59	28·7	0·81	0·26
Pyrethrum marc	12·7	8·1	6·8	63	66	22·9	0·60	0·27
Sisal waste	5·3	2·1	29·5	64	65	24·7		
Sorghum stalks with heads and some grain	7·8	4·1	15·9	69	71	16·1	0·05	0·34
Sunflower heads with some seed	14·0	9·2	5·6	61	65	23·9	0·82	0·35
Sunflower heads without seed	7·4	3·7	17·0	67	68	20·7	1·14	0·21
CEREALS (GREEN FODDER)—								
Maize, tasselling, for ensilage	8·1	4·0	13·2	57	59	32·5		
Maize cobs forming, for ensilage	9·3	4·9	10·7	57	59	30·0	0·28	0·21
Maize milky cob stage, for ensilage	6·8	3·0	17·8	56	57	33·3		
Millet, 50% flowering	13·8	8·8	5·5	57	61	29·1	0·43	0·51
Oats, 12 inches high, for grazing	35·3	32·7	1·2	72	85	15·9	0·44	0·30
Oats, 18-24 inches high, for grazing	20·2	15·4	3·0	62	68	21·9	0·34	0·24
Oats, early flowering, for ensilage	9·1	5·0	11·8	64	66	22·0	0·30	0·14
Oats, full flower, for ensilage	8·1	4·1	13·8	61	63	26·5	0·29	0·15
Sorghum almum (Columbus grass):								
piping and some flowering heads, cut in late July at Kitale	14·5	9·4	5·1	57	61	29·0		
regrowth from above, cut in early September at Kitale	15·0	9·9	4·8	57	61	28·7		
regrowth from above, leaf only, cut in mid-October at Kitale	13·4	8·4	5·9	58	61	29·6		
regrowth from above, piping, some flowering heads, cut in early December at Kitale	12·3	7·4	6·8	58	61	30·2		
regrowth from above, piping, some flowering heads, cut in mid-January at Kitale	10·8	6·1	8·3	57	59	31·1		
Sorghum niloticum, var. *kavirondense*, (Perennial Kavirondo Sorghum):								
piping and some flowers emerging, cut in early August at Kitale	10·7	6·0	8·5	57	59	31·1		
regrowth from above, piping and some flowering heads, cut in mid-September at Kitale	19·1	13·9	3·3	60	66	26·5		
regrowth from above, piping and some flowering heads, cut in late October at Kitale	15·3	10·2	4·7	58	62	28·6		

DESCRIPTION	Crude Protein	Digestible Crude Protein	Nutritive Ratio	Total Digestible Nutrients	Gross Digestible Energy	Crude Fibre	Ca	P
	CP	DCP	NR	TDN	GDE	CF		
Sorghum niloticum, etc.—(*Contd.*)								
regrowth from above, piping and some flowering heads, cut in mid-November at Kitale	14·8	9·7	4·9	57	61	28·9		
regrowth from above, piping and some flowering heads, cut in late December, at Kitale	11·7	6·9	7·4	58	61	30·6		
regrowth from above, piping and some flowering heads, cut in mid-January at Kitale	11·9	7·1	7·1	58	61	30·5		
Sorghum sudanense (Sudan grass):								
piping and some flowering heads emerging, cut in late July at Kitale	14·2	9·2	5·2	57	61	29·2		
regrowth from above, piping with a few flowering heads, cut in mid-August at Kitale	15·8	10·7	4·5	59	63	28·3		
regrowth from the October cut, piping with a few flowering heads, cut in early November at Kitale	15·4	10·3	4·6	58	62	28·5		
regrowth from above, piping with a few flowering heads, cut in mid-December at Kitale	10·8	6·1	8·3	57	59	31·1		
regrowth from above, occasional flowering heads, cut in mid-January at Kitale	9·5	5·0	10·2	56	58	31·8		
50% flowering, a local variety grown at Katumani	13·5	8·5	5·8	58	61	29·6		
50% flowering, "Green leaf" var. grown at Katumani	11·1	6·3	7·9	56	58	30·9		
"Sweet Sudan", 50% flowering, Katumani	10·8	6·1	8·3	57	59	31·1		
"Piper" 50% flowering, Katumani	13·6	8·6	5·6	57	60	29·5		
Sorghum sp. (Velvet sorghum):								
piping and some flowers emerging, cut in early August at Kitale	11·2	6·4	7·9	57	60	30·8		
regrowth from above, young leaf, cut in mid-September at Kitale	19·3	14·2	3·2	60	66	26·4		
regrowth from above, leafy, cut in early November at Kitale	16·2	11·0	4·4	59	63	28·1		
regrowth from above, piping and early flowers, cut in late December at Kitale	12·5	7·6	6·6	58	61	30·1		
regrowth from above, leafy, cut in mid-January at Kitale	14·9	9·8	4·9	58	62	28·8		
CEREAL GRAIN AND CEREAL PRODUCTS:—								
Barley grain	9·3	5·7	12·9	74	76	5·6	0·05	0·30
Barley meal	8·4	4·9	15·5	81	83	4·4	0·08	0·32
Maize grain	10·2	6·6	11·2	81	84	1·7	0·05	0·29
Maize germ meal	9·7	6·1	12·1	80	82	5·0	0·06	0·58
Maize meal (white)	8·6	5·2	14·8	82	85	1·9	0·03	0·19
Maize meal (yellow)	9·2	5·7	13·2	81	83	1·9	0·04	0·18
Millet, grain	11·8	7·8	8·3	73	76	9·6	0·05	0·24
Oats, grain	9·9	6·1	11·2	74	76	8·8	0·11	0·32
Pollards	16·7	12·7	4·6	71	76	8·4	0·14	0·96
Rice grain (padi)	8·5	5·3	15·5	87	89	0·2	0·03	0·12
Rice dust	2·5	0·4	86·5	35	35	40·8	0·09	0·10
Rye	15·5	11·6	5·5	75	80	4·1		
Sorghum	12·2	8·4	7·9	75	78	5·0		
Wheat grain	14·2	10·4	6·3	76	80	2·5	0·05	0·45
Wheat bran	13·8	9·5	6·2	68	72	14·0	0·18	1·13
OIL SEEDS AND OTHER SEEDS:—								
Cotton seed	17·1	12·3	4·1	63	68	22·1		
Dolichos lablab bean	23·5	19·7	2·6	71	79	10·6		
Linseed, locally grown	23·8	20·3	2·6	73	81	6·9		
Lentils	26·3	23·4	2·2	75	84	4·2		
Lupin seed	33·4	30·4	1·3	70	82	15·7		
Niger oil seed	23·2	19·4	2·7	71	79	10·0		
Soya bean	43·1	43·0	1·0	86	100	5·0		
Sunflower seed	24·7	19·2	2·0	58	64	32·4		

DESCRIPTION	Crude Protein	Digestible Crude Protein	Nutritive Ratio	Total Digestible Nutrients	Gross Digestible Energy	Crude Fibre	Ca	P
	CP	DCP	NR	TDN	GDE	CF		
STRAWS AND STOVERS:—								
Dolichos, leaves and vines	19·9	15·1	3·2	63	69	20·5	1·44	0·15
Dolichos, bean pods containing some seed	14·1	9·0	5·4	58	62	29·6	0·40	0·14
Maize stover	3·7	1·0	47·9	49	49	39·6	0·11	0·04
Oat straw	5·3	1·8	25·7	48	49	41·9		
Sorghum stover	2·8	0·5	74·1	38	38	43·1		
Soya bean stover	6·0	2·4	22·4	56	57	33·7		
Sunflower stover	2·0	0·1	120·0	12	12	56·2	0·40	0·02
HERBS:—								
Burnett, October sample from Kitale	18·9	14·7	3·6	68	74	11·9	0·99	0·31
Burnett, January sample from Kitale	12·5	8·4	7·6	72	75	11·6	1·18	0·26
Chicory, October, sample from Kitale	13·8	9·5	6·2	68	72	13·9	1·56	0·23
Chicory, January, sample from Kitale	15·4	11·0	5·0	66	70	15·0	1·67	0·20
Plantain, October, sample from Kitale	15·9	11·6	4·9	68	73	13·3	1·54	0·29
Plantain, January, sample from Kitale	12·2	8·1	7·8	71	74	11·4	1·53	0·21
Yarrow, October, sample from Kitale	19·3	14·9	3·5	67	73	14·7	1·05	0·32
HAYS:—								
Brome grass hay, early flowering	8·6	4·4	12·3	59	61	30·4	0·36	0·13
Cocksfoot	8·8	4·5	11·8	58	60	31·1	0·19	0·11
Guinea grass with lucerne and clover, full flowering	15·7	10·7	4·6	60	64	26·5	1·25	0·24
Kenya white clover, aftermath of a seeds harvest	15·1	10·0	4·8	58	62	28·7		
Kikuyu grass, young and leafy	14·1	9·1	5·4	58	62	28·4	0·49	0·28
Lucerne, flowering	18·9	13·6	3·2	57	62	28·9	1·01	0·33
Molasses grass with lucerne and clover, flowering	17·9	12·8	3·6	59	64	25·7	1·08	0·26
Oat hay	6·1	2·6	21·9	60	61	29·4	0·26	0·09
Rhodes grass, in full flower,	7·0	3·1	17·0	56	57	33·1		
Rhodes, grass, young and leafy	14·7	9·6	5·0	58	62	28·9		
Rhodes grass, with lucerne and clover, flowering	15·2	10·0	4·7	57	61	29·6	1·26	0·25
Setaria (Nandi), young and leafy	15·1	10·0	4·8	58	62	28·7		
Setaria, with lucerne and clover, full flowering	11·8	7·0	7·2	57	60	29·3	0·64	0·10
Veldt, i.e. natural grassland	4·0	1·1	41·7	56	56	40·3	0·25	0·14
SILAGES:—								
Lupins with very young pods	16·3	11·2	4·3	59	63	28·0		
Maize, pre-cob-forming stage	9·8	5·3	9·8	57	59	31·8		
Oats and lupins cut at 9 inches	10·9	6·2	8·3	58	60	31·0		
Oats and lupins cut at 18 inches	15·9	10·8	4·5	59	63	28·3		
Oats and lupins cut at 24 inches	10·0	5·5	9·6	58	60	31·5		
Oats and lupins cut at 36 inches	7·6	3·6	14·8	57	58	32·8		
Oats, cut at the piping stage	6·7	2·9	18·2	56	57	33·3		
LEGUMES:—								
Bokhara sweet clover, early flowering	14·3	9·0	5·1	54	58	33·7		
Glycine javanica, early flowering	20·4	15·2	3·0	62	68	27·7	1·32	0·33
Hubam sweet clover, young growth	26·1	22·0	2·1	68	77	17·9	2·67	0·26
Indigofera subulata, early flowering	14·9	10·3	5·2	64	68	18·6	1·77	
Kenya white clover, early flowering	20·7	16·0	3·0	64	70	20·9		
Kenya white clover, advanced flowering	14·3	9·4	5·4	60	64	25·0	1·84	0·19
Louisiana clover, flowering	13·8	8·8	5·5	57	61	29·4		0·25
Lucerne, 12-18 inches high	24·4	19·6	2·2	63	71	24·1	1·20	0·38
Lucerne, pre-budding	21·0	15·8	2·8	60	66	26·9	1·17	0·34
Lucerne, budding, occasional flowers	18·9	13·7	3·3	59	64	28·3	1·17	0·30
Lucerne, flowering	19·0	13·6	3·2	57	62	30·8	1·27	0·24
Lupins, blue, 9 inches high	25·3	21·6	2·2	69	78	12·0	1·93	0·27
Lupins, blue, 15 inches high	24·3	20·0	2·3	66	74	18·1	1·50	0·31
Lupins, blue, 17 inches high	20·9	16·3	3·0	65	72	18·2	1·83	0·33
Lupins, blue, 32 inches high	24·2	20·2	2·4	69	77	13·9	1·73	0·32
Lupins, blue, 36 inches high	16·0	10·9	4·5	60	64	26·7	1·27	0·23
Lupins, sweet, in full flower	14·9	9·8	4·9	58	62	28·8		0·14
Serradella (*Ornithopus sativa*), 18 inches high	24·4	20·1	2·3	66	74	17·6	1·21	0·24

Description	Crude Protein	Digestible Crude Protein	Nutritive Ratio	Total Digestible Nutrients	Gross Digestible Energy	Crude Fibre	Ca	P
	CP	DCP	NR	TDN	GDE	CF		
Serradella, early podding	11·2	6·7	8·1	61	64	25·6	1·34	0·26
Sesbania Sesban, ripe and unripe pods with seeds	14·0	9·0	5·4	58	62	29·3		
Subterranean clover, early flowering	18·2	13·8	3·9	68	73	14·6	1·08	0·25
Subterranean clover, full flower	10·0	6·0	10·5	69	71	16·7		0·20
Trifolium rueppellianum, full flower	18·6	13·9	3·5	63	69	20·1		0·16
Trifolium semipilosum, full flower	16·3	11·4	4·4	62	67	24·2	2·05	0·24
Vigne schimperi, late flowering	23·2	18·3	2·3	60	67	25·1	1·51	0·33
CONCENTRATES:—								
Copra cake	25·3	21·0	2·1	65	73	18·6		
Cottonseed cake	20·3	14·7	2·8	56	62	33·9		
Cottonseed cake	37·5	35·0	1·1	74	88	18·4		
Groundnut cake	48·5	48·5	0·6	78	97	4·6		
Linseed cake (Ethiopian)	29·9	26·8	1·7	72	83	12·3		
GRASSES:—								
Aristida mutabilis, standing hay at Turkana	5·5	2·1	25·1	55	56	36·7	0·29	0·09
Aristida mutabilis, standing hay at Esageri	3·7	1·0	49·0	50	50	37·9	0·16	0·07
Cocksfoot (*Dactylis glomerata*):								
5-6 inches high, taken in May at Molo	26·8	22·6	2·0	68	77	19·1	0·37	0·36
5-6 inches high, taken in August at Molo	21·9	16·9	2·6	63	70	25·0	0·34	0·35
Elephant or Napier grass (*Pennisetum purpureum*):								
January growth	11·4	6·6	7·4	55	58	32·7		
June growth	7·9	3·8	13·8	56	58	32·7		
November growth	7·0	3·2	17·4	59	60	31·4		
2½-3 ft. high, Uganda var.	10·9	6·3	8·5	60	62	27·2	0·16	0·37
2½-3 ft. high, Cameroons var.	10·0	5·5	9·6	58	60	30·0	0·16	0·09
2½-3 ft. high, Gold Coast var.	11·2	6·4	7·9	57	60	31·4	0·24	0·13
2½-3 ft. high, Kitui var.	10·0	5·5	9·6	58	60	30·5	0·17	0·15
2½-3 ft. high, Minna var.	12·2	7·5	6·9	59	62	26·3	0·18	0·21
2½-3 ft. high, Songhor var.	11·3	6·6	7·8	58	61	30·6	0·16	0·15
Guinea grass (*Panicum maximum*):								
Kampi ya Mawe var., flowering	7·0	3·1	16·6	55	56	36·7	0·35	0·13
Mackinnon Road. var., flowering	8·7	4·3	11·5	54	56	37·0	0·40	0·14
Sigor var., flowering	8·3	3·8	12·0	49	51	41·9	0·27	0·12
Trans Nzoia var. in full flower	12·0	7·0	6·9	55	58	34·7		
Hyparrhenia dissoluta:								
Young leaf, April	14·5	9·5	5·2	59	63	27·1	0·46	0·29
Leafy, early May	9·1	4·6	10·7	54	56	35·0	0·35	0·20
Stemmy, late May	4·6	1·4	33·1	48	49	41·2	0·22	0·14
Flowering, very stemmy, mid-June	3·8	1·0	44·7	46	46	42·3	0·23	0·12
Post-flowering stage, mid-July	2·8	0·5	74·1	38	38	42·3	0·32	0·08
Kikuyu grass (*Pennisetum clandestinum*):								
July growth on South Kinangop	20·8	15·9	2·9	62	68	22·8	0·33	0·24
August growth on South Kinangop	16·9	11·9	4·1	61	66	24·1	0·46	0·29
September growth on South Kinangop	11·6	7·1	7·8	62	65	24·0	0·39	0·23
October, growth on South Kinangop	12·2	7·6	6·9	60	63	25·0	0·29	0·19
December growth on South Kinangop	10·9	6·5	8·7	63	66	22·3	0·40	0·17
February growth on South Kinangop	11·2	6·8	8·3	63	66	22·8	0·61	0·12
March growth on South Kinangop	19·3	14·2	3·2	60	66	25·8	0·41	0·20
April growth on South Kinangop	17·9	12·8	3·6	59	64	25·8	0·53	0·29
May growth on South Kinangop	16·7	11·9	4·2	62	67	22·2	0·42	0·27
June growth on South Kinangop	13·9	9·2	5·8	63	67	21·9	0·48	0·26
Molasses grass (*Melinis minutiflora*):								
Leafy, three months after planting	17·3	12·2	3·9	60	65	25·8	0·18	0·24
Third year sward, cut weekly in February, at Kitale	4·5	1·5	37·2	57	58	29·9	0·25	0·10
Third year sward, cut weekly in February, at Kitale	5·3	2·1	28·8	63	64	27·2	0·23	0·12
Third year sward, cut weekly in March, at Kitale	5·2	2·0	29·5	61	62	26·3	0·25	0·14
Third year sward, cut weekly in March, at Kitale	5·6	2·3	26·3	63	64	27·3	0·20	0·15
Third year sward, cut weekly in March, at Kitale	4·5	1·5	37·2	57	58	30·7	0·20	0·14

DESCRIPTION	Crude Protein	Digestible Crude Protein	Nutritive Ratio	Total Digestible Nutrients	Gross Digestible Energy	Crude Fibre	Ca	P
	CP	DCP	NR	TDN	GDE	CF		
Molasses grass (*Melinis minutiflora*):—(*Contd.*)								
Third year sward, cut weekly in March, at Kitale	5·4	2·2	27·5	63	64	26·5	0·33	0·15
Third year sward, cut weekly in April, at Kitale	7·6	3·7	15·5	61	62	27·6	0·38	0·19
Third year sward, cut weekly in April, at Kitale	7·3	3·5	16·6	62	63	27·3	0·34	0·27
Third year sward, cut weekly in April, at Kitale	8·1	4·1	13·8	61	63	27·0	0·41	0·31
Third year sward, cut weekly in April, at Kitale	7·7	3·8	15·1	61	63	28·1	0·40	0·24
Third year sward, cut in May at Kitale	8·8	4·6	12·0	60	63	26·9	0·45	0·35
Third year sward, regrowth, 1½ inches high, cut in mid-August at Kitale	14·8	10·0	5·1	61	65	23·0	0·39	0·43
Third year sward, regrowth, 2-4 inches, high, cut in early September, at Kitale	11·8	7·2	7·6	62	65	24·6	0·37	0·49
Third year sward, regrowth, 5½ inches high, cut in late September at Kitale	8·8	4·7	12·3	63	65	24·3	0·39	0·35
Third year sward, regrowth, flowering, cut in early October at Kitale	8·3	4·3	13·8	64	66	24·6	0·47	0·35
Third year sward, regrowth, late flowering, cut in late October at Kitale	6·0	2·6	23·4	63	64	25·0	0·38	0·25
Third year sward, regrowth, late flowering, cut in mid-November at Kitale	5·1	1·9	29·5	58	59	29·4	0·34	0·23
Paspalum commune, 12-20 inches high	14·9	10·1	5·1	62	66	23·6	0·37	0·10
Paspalum dilatatum, 12 inches high	12·8	8·0	6·5	60	63	27·5	0·28	0·11
Paspalum malacophyllum, 11 inches high	14·7	9·8	5·1	60	64	25·9	0·60	0·09
Paspalum paniculatum, 10-17 inches high	16·7	11·7	4·2	61	66	24·7	0·39	0·09
Paspalum regnelii, 10-17 inches high	14·4	9·6	5·4	61	65	24·6	0·40	0·08
Pennisetum schimperi, early flowering	9·0	4·5	11·0	54	56	35·6	0·36	0·14
Pennisetum mezianum, early flowering	10·8	6·1	8·1	56	58	32·1	0·55	0·28
Pennisetum stramineum:								
May growth on the Laikipia	6·1	2·4	20·9	53	54	37·2	0·52	0·12
Early June growth on the Laikipia	6·4	2·6	19·1	52	53	40·2	0·54	0·14
Late June growth on the Laikipia	5·2	1·8	26·9	50	51	39·3	0·45	0·11
Early July growth on the Laikipia	5·5	2·0	25·1	52	53	37·0	0·55	0·11
Late July growth on the Laikipia	4·6	1·5	33·9	52	53	37·6	0·47	0·10
Early August growth on the Laikipia	4·5	1·4	35·5	51	52	36·8	0·55	0·08
Late August growth on the Laikipia	4·0	1·2	42·7	52	52	37·6	0·57	0·07
Early September growth on the Laikipia	2·6	0·5	89·1	45	45	37·6	0·44	0·06
Late September growth on the Laikipia	2·4	0·4	100·0	40	40	40·0	0·31	0·05
Red Oat grass (*Themeda triandra*):								
May growth on the Laikipia	6·7	2·9	17·8	55	56	35·2	0·24	0·12
Early June growth on the Laikipia	4·4	1·4	36·3	52	53	36·5	0·31	0·08
Late June growth on the Laikipia	4·8	1·7	32·4	57	58	34·2	0·46	0·09
Early July growth on the Laikipia	5·8	2·3	22·9	55	56	35·5	0·38	0·12
Late July growth on the Laikipia	3·8	1·1	47·9	54	54	34·9	0·47	0·09
Early August growth on the Laikipia	3·1	0·7	66·1	47	47	37·0	0·45	0·08
Late August growth on the Laikipia	3·2	0·8	63·1	51	51	35·7	0·41	0·08
Early September growth on the Laikipia	2·7	0·5	83·2	42	42	35·7	0·50	0·07
Late September growth on the Laikipia	2·7	0·5	83·2	42	42	34·7	0·39	0·07
Regenerating after a February burn on the Laikipia, 10th March	17·2	12·1	3·9	59	64	27·5	0·83	0·31
Regenerating after a February burn on the Laikipia, 20th March	14·6	9·5	5·0	57	61	29·0	0·73	0·31
Regenerating after a February burn on the Laikipia, 27th March	12·9	8·0	6·2	58	61	30·0	0·74	0·25
Regenerating after a February burn on the Laikipia, 3rd April	12·6	7·7	6·5	58	61	30·1	0·80	0·23
Regenerating after a February burn on the Laikipia, 14th April	12·0	7·2	7·1	58	61	30·4	0·63	0·31
Regenerating after a February burn on the Laikipia, 22nd April	12·6	7·7	6·5	58	61	30·1	0·48	0·28
Regenerating after a February burn on the Laikipia, 15th May	6·5	2·8	19·5	57	58	33·4	0·26	0·17
Regenerating after a February burn on the Laikipia, 31st May	6·1	2·5	21·4	56	57	33·6	0·21	0·14

DESCRIPTION	Crude Protein CP	Digestible Crude Protein DCP	Nutritive Ratio NR	Total Digestible Nutrients TDN	Gross Digestible Energy GDE	Crude Fibre CF	Ca	P
Rhodes grass (*Chloris gayana*):								
Young, leafy	19·3	14·3	3·3	61	67	24·4		
With some flowers	7·8	3·7	14·1	56	57	32·7		
Third year pasture, 4½ inches high, cut in mid-February at Kitale	5·9	2·4	22·9	57	58	32·0	0·55	0·26
Third year pasture, 7 inches high, cut in mid-March at Kitale	6·3	2·7	20·9	59	60	31·3	0·56	0·31
Third year pasture, 9 inches high, cut in mid-April at Kitale	12·6	7·7	6·5	58	61	29·2	0·58	0·51
Third year pasture, 14 inches high, occasional flowering cut in mid-May at Kitale	8·9	4·5	11·5	56	58	32·8	0·48	0·50
Third year pasture, in full flower, cut in early June at Kitale	7·4	3·4	15·5	56	57	33·7	0·42	0·29
Third year pasture, regrowth, 3-5 inches high, cut in mid-August at Kitale ..	14·4	9·3	5·1	57	61	30·0	0·39	0·56
Third year pasture, regrowth 10-14 inches high, cut in mid-September at Kitale ..	12·8	8·0	6·5	60	63	27·2	0·53	0·47
Third year pasture, regrowth, some flowering heads, cut in mid-October at Kitale	6·6	2·9	19·1	58	59	29·8	0·54	0·29
Third year pasture, regrowth, full flowering, cut in mid-November at Kitale ..	7·2	3·4	16·6	60	61	29·1	0·61	0·40
Ronpha grass, very leafy, two months after planting	25·1	20·4	2·1	63	71	23·2		
Ronpha grass, very leafy, four months after planting	33·9	31·7	1·4	76	89	10·4	0·49	0·36
Ronpha grass, flowering	16·2	11·1	4·4	60	64	28·1		
Ronpha grass, mixed "green" and "burn" of the dry season	14·5	9·5	5·2	59	63	27·1	0·29	0·17
Rough grazing from natural grassland at Kitale, late April, unrestricted growth ..	7·5	3·5	15·1	56	57	33·6	0·42	0·21
Rough grazing from natural grassland at at Kitale, early May, unrestricted growth	6·8	2·9	17·4	53	54	36·0		
Rough grazing from natural grassland at Kitale, early, May unrestricted growth ..	6·4	2·7	19·5	55	56	36·0		
Rough grazing from natural grassland at Kitale, early June, unrestricted growth ..	6·3	2·6	19·7	53	54	38·2		
Rough grazing from natural grassland at Kitale, early July, unrestricted growth ..	5·6	2·2	25·1	57	58	33·9	0·54	0·26
Rough grazing from natural grassland at Kitale, early September, unrestricted growth	7·7	3·6	14·5	56	57	32·8	0·55	0·21
Rough grazing from natural grassland at at Kitale, early November, unrestricted growth	8·7	4·4	11·8	56	58	32·2	0·42	0·19
Rough grazing from natural grassland at Kitale, late December, unrestricted growth	2·8	0·6	77·6	47	47	35·5		
Rye grass, Westerwolths, hay stage of growth at Molo	9·3	5·0	11·0	60	62	27·0	0·30	0·05
Rye grass, Perennial, leafy May growth at Molo	24·0	19·2	2·3	63	71	23·0	0·36	0·35
Rye grass, Perennial, leafy August growth at Molo	14·7	9·6	5·0	58	62	28·9	0·34	0·39
Rye grass, H.1., leafy August growth at Molo	23·1	18·2	2·4	62	69	24·3		
Rye grass, H.1., leafy October growth at Molo	15·9	10·9	4·5	60	64	25·6		
Setaria (Nandi) (*Setaria sphacelata*):								
First year pasture, September grass at Njoro	19·4	14·3	3·2	60	66	25·6	0·31	0·20
First year pasture, October grass at Njoro	14·9	9·9	5·0	59	63	27·3	0·29	0·17
First year pasture, November grass at Njoro	13·4	8·4	5·9	58	62	29·4	0·31	0·14
First year pasture, December grass at Njoro	8·9	4·6	11·8	59	62	29·6	0·31	0·10

DESCRIPTION	Crude Protein	Digestible Crude Protein	Nutritive Ratio	Total Digestible Nutrients	Gross Digestible Energy	Crude Fibre	Ca	P
	CP	DCP	NR	TDN	GDE	CF		
Setaria (Nandi) (*Setaria sphacelata*):—(*Contd.*)								
First year pasture, January grass at Njoro	8·6	4·4	12·3	59	61	29·2	0·34	0·07
First year pasture, February grass at Njoro	6·9	3·1	17·8	58	59	31·1	0·31	0·07
First year pasture, March grass at Njoro	11·9	7·3	7·2	60	63	25·5	0·39	0·13
Second year pasture, 9 inches high, end of March at Kitale	15·1	10·3	5·0	62	66	22·9	0·38	0·23
Second year pasture, 22 inches high, end of April at Kitale	12·5	7·8	6·8	61	64	26·8	0·31	0·22
Second year pasture, full flower, end of May at Kitale	6·2	2·5	20·4	54	55	38·1	0·20	0·23
Second year pasture, very mature grass, end of June at Kitale	5·1	1·8	28·2	53	54	37·4	0·22	0·23
Second year pasture, very mature grass, end of July at Kitale	5·2	1·8	26·3	49	50	42·4	0·26	0·09
Second year pasture, regrowth, 12 inches high, early August at Kitale	12·1	7·3	6·9	58	61	29·8	0·32	0·41
Second year pasture, regrowth, 17 inches early September, at Kitale	10·0	5·6	9·8	60	62	27·9	0·37	0·36
Second year pasture, regrowth, early flowering, early October at Kitale	7·4	3·5	15·9	59	60	31·3	0·32	0·14
Second year pasture, regrowth, full flowering, mid-October at Kitale	5·1	1·9	28·8	57	58	32·1	0·36	0·19
Slender Guinea grass (*Panicum maximum*, var. *trichoglume*) early flowering	18·6	13·5	3·4	59	64	26·8		
Slender Guinea grass general flowering	11·7	6·9	7·4	58	61	29·9	0·54	0·26
Star grass (*Cynodon dactylon*):								
Second year pasture, 5½ inches high, mid-February at Kitale	12·9	8·2	6·3	60	63	25·7	0·67	0·07
Second year pasture, 5½ inches high, mid-March at Kitale	15·0	10·2	5·0	61	65	23·5	0·58	0·13
Second year pasture, 10 inches high, mid-April at Kitale	16·5	11·5	4·2	60	65	25·3	0·50	0·21
Second year pasture, general flowering, mid-May at Kitale	10·9	6·2	8·3	58	60	30·0	0·50	0·18
Second year pasture, general flowering, mid-June at Kitale	9·2	4·8	10·7	56	58	31·7	0·52	0·14
Second year pasture, general flowering, mid-July at Kitale	7·8	3·7	14·1	56	57	33·4	0·48	0·17
Second year pasture, regrowth, 4-6 inches high, early August at Kitale	25·0	20·4	2·1	63	71	22·7	0·40	0·52
Second year pasture, regrowth, 6 inches high, early September at Kitale	18·9	14·0	3·4	62	68	22·5	0·58	0·42
Second year pasture, regrowth, 7-9 inches high, early October at Kitale	11·5	7·0	7·9	62	65	24·6	0·67	0·22
Second year pasture, regrowth, full flowering, early November	8·3	4·2	13·2	60	62	30·3	0·69	0·15
GRASS AND LEGUME MIXTURES:—								
Cocksfoot with Bromus and lucerne, leafy	25·3	20·7	2·1	64	72	22·5		
Cocksfoot and lucerne, young and leafy	23·1	18·2	2·4	62	69	24·3		
Molasses grass and Bamenda clover; third year sward:								
Mid-April cut at Kitale	6·3	2·6	20·4	56	57	33·5		
Mid-May cut at Kitale	9·3	4·9	10·5	56	58	31·9		
Mid-June cut at Kitale	7·6	3·6	14·8	57	58	32·8		
Mid-July cut at Kitale	7·4	3·4	15·5	56	57	32·9		
Mid-August cut at Kitale	8·7	4·4	11·8	56	58	32·2		
Mid-September cut at Kitale	8·2	4·0	13·2	57	59	32·5		
Mid-October cut at Kitale	8·1	4·0	13·2	57	59	32·5		
Mid-November cut at Kitale	7·0	3·2	17·0	58	59	33·1		
Mid-December cut at Kitale	7·2	3·3	16·2	57	58	33·0		
Molasses grass and lucerne, leafy	10·6	6·0	8·7	58	60	31·2		
Molasses grass and *Trifolium rueppellianum*, leafy	11·4	6·6	7·6	57	60	30·8		

DESCRIPTION	Crude Protein CP	Digestible Crude Protein DCP	tritive Ratio NR	Total Digestible Nutrients TDN	Gross Digestible Energy GDE	Crude Fibre CF	Ca	P
Molasses grass and Kenya white clover, hay stage	8·7	4·4	11·8	56	58	32·2		
Rhodes grass and Bamenda clover; third year sward:								
Mid-April cut at Kitale	8·4	4·2	12·6	60	62	32·4		
Mid-May cut at Kitale	7·9	3·8	13·8	56	58	32·7		
Mid-June cut at Kitale	7·0	3·2	17·0	58	59	33·1		
Mid-July cut at Kitale	7·9	3·8	13·8	56	58	32·7		
Mid-August, cut at Kitale	9·1	4·7	11·0	56	58	32·0		
Mid-September cut at Kitale	7·0	3·2	17·0	58	59	33·1		
Mid-October cut at Kitale	8·1	4·0	13·2	59	61	32·5		
Mid-November, cut at Kitale	7·2	3·3	16·2	57	58	33·0		
Mid-December cut at Kitale	7·2	3·3	16·2	57	58	33·0		
Rhodes grass and Kenya white clover; third year sward:								
Mid-April cut at Kitale	6·0	2·4	22·4	56	57	33·7		
Mid-May cut at Kitale	8·4	4·2	12·6	60	62	32·4		
Mid-June cut at Kitale	12·1	7·3	6·9	58	61	30·3		
Mid-July cut at Kitale	9·9	5·4	9·8	58	60	31·6		
Mid-August cut at Kitale	11·1	6·4	7·9	57	60	30·9		
Mid-September cut at Kitale	12·3	7·4	6·8	58	61	30·2		
Mid-October cut at Kitale	12·3	7·4	6·8	58	61	30·2		
Mid-November cut at Kitale	14·7	9·6	5·0	58	62	28·9		
Mid-December cut at Kitale	12·8	7·9	6·3	58	61	30·0		
Rye grass and subterranean clover, young growth	23·4	18·9	2·5	66	74	18·9		
Setaria and Bamenda clover; third year sward:								
Mid-April cut at Kitale	9·1	4·7	11·0	56	58	32·0		
Mid-May cut at Kitale	8·3	4·1	12·9	57	59	32·4		
Mid-June cut at Kitale	8·1	4·0	13·2	57	59	32·5		
Mid-July cut at Kitale	6·5	2·8	19·5	57	58	33·4		
Mid-August cut at Kitale	8·5	4·3	12·3	57	59	32·3		
Mid-September cut at Kitale	10·4	5·8	8·9	57	59	31·3		
Mid-October cut at Kitale	10·8	6·1	8·1	56	58	31·1		
Mid-November cut at Kitale	8·0	3·9	13·5	57	59	32·6		
Mid-December cut at Kitale	9·1	4·7	11·0	56	58	32·0		
Setaria, Louisiana white clover and lucerne; third year sward:								
Mid-April cut at Kitale	11·5	6·7	7·6	58	61	30·7		
Mid-May cut at Kitale	10·9	6·2	8·3	58	60	31·0		
Mid-June cut at Kitale	11·6	6·8	7·4	57	60	30·6		
Mid-July cut at Kitale	7·2	3·3	16·2	57	58	33·0		
Mid-August cut at Kitale	10·3	5·7	9·1	58	60	31·3		
Mid-September cut at Kitale	11·8	7·0	7·2	57	60	30·5		
Mid-October cut at Kitale	14·9	9·8	4·9	58	62	28·8		
Mid-November cut at Kitale	8·3	4·1	12·9	57	59	32·4		
Mid-December cut at Kitale	11·3	6·6	7·8	58	61	30·8		

INSECT PESTS IN THE COAST PROVINCE OF KENYA

I—MANGO

By P. E. Wheatley, Entomologist, Department of Agriculture, Kenya

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A wide range of insect pests attack mango, but generally speaking the damage they cause, although sometimes considerable, is not so severe as on the majority of tree crops on the Kenya coast and insecticidal control measures have been rarely employed in the past. However, the recently developed trade in air-freighting mangoes to Europe has created a market for a very high grade of fruit unblemished by fungal or insect attack. Insect blemishes are normally caused by scale insects and the internal quality of the fruit is unimpaired. Therefore the need for insecticidal control measures for scale insects on mangoes depends not only upon the severity of infestation, but also upon the type of fruit which one is trying to produce. The local East African market at present does not discriminate between fruit with and without minor blemishes, but the luxury Covent Garden trade very definitely does and if fruit are to be grown for this latter market, spraying may be necessary even for very low scale infestations.

Generally speaking, insecticidal treatments for other pests will not be necessary except in the case of young mango seedlings, which may suffer seriously from thrips, red spider and leaf galls as well as scale insects.

Scale Insect (*Aulacaspis cinamoni*)

The adult female scale is white in colour, roughly circular and about $\frac{1}{8}$ of an inch in diameter. Females usually occur singly on the leaves although they may be found on the fruit, and are rarely present in large numbers. The nymphs of male scales are very much more numerous, very small, white, elongate and about 1/20th of an inch long. They also are found on the leaves but occur in groups of 10 to 40 covering an area of $\frac{1}{4}$ to $\frac{3}{4}$ in. square. The adult male is a small winged insect which does not feed and is rarely seen.

Life History

Eggs are laid under the hard shell of the female and remain there protected from insecticidal sprays, until the young "crawlers" hatch out. These have functional legs and crawl away from the parent female to settle down and feed. The later stages are sedentary.

Damage

All scale insects suck the sap of plants causing a general debilitation. In addition, a yellow leaf chlorosis often occurs at the feeding sites, and this is the case with *Aulacaspis*. In the cases where this scale feeds on the fruit a yellow chlorotic patch results which cannot be removed by washing, and this impairs the appearance of the fruit.

Control

Control of scale insects on mango has not been fully studied. Full cover sprays at high pressure of malathion at three pints of a 50 per cent emulsion or diazinon at $1\frac{1}{4}$ pints of a 60 per cent emulsion, in 100 gallons of water is likely to give a good control of all species of scales occurring on mango if applied twice with a three-week interval between sprayings.

Our present state of knowledge indicates that where very high grade fruits are being produced, this double application should be applied so that the second spray is completed just before the main flowering season. A further spray may be required after the fruit has set if there are signs of the reappearance of scale insects. In cases where fruit are being produced for the local market only, the timing of sprays should depend upon the build-up of scale, a double application being made in the first instance. Care should be taken not to spray during flowering to avoid killing pollinating insects.

Scale Insect (*Pulvinaria* sp.)

The scales are up to 1/16th of an inch in length, and may be found in large numbers on leaves, green shoots and frequently around the stem end of the fruit. The young scales are oval, flattened and green in colour. The adult female is brown and produces a large white fluffy egg-sac, up to 3/16th of an inch in diameter, which covers and protects the eggs she lays.

Life History

Basically this is similar to that of *Aulacaspis.*

Damage

Damage due to sap-sucking is similar to that of *Aulascaspis,* although very little chlorosis occurs. However this scale excretes a copious volume of "honey-dew", a clear sugary fluid which contaminates the tree. A fungus, "Black Sooty Mould", grows on the honeydew and its mycelium forms a thin black skin which covers leaves, stems and fruit. This covering masks the chloropyll of the leaves and may reduce photosynthesis to a considerable extent. Fortunately, it can be easily washed off the fruit. The red *maji-moto* ant frequently attends *Pulvinaria,* and although the presence of these ants may be beneficial to the scale, they feed on the honeydew and thus considerably reduce the growth of black sooty mould. The scale can produce very large colonies in the absence of *maji-moto* ants and it is doubtful whether the overall effect of the ant can be regarded as harmful.

Control

By the application of malathion or diazinon as for *Aulacaspis. Pulvinaria* forms distinct colonies which are normally restricted to a small group of neighbouring trees, or even to one tree or a part of a tree. Therefore a spot treatment of affected trees only will probably prove effective. Give a second application after a three-week interval to kill crawlers which hatch from eggs protected in egg-sacs at the time of the first spray. The whole of an infested tree should be sprayed this second time even though the scale appears to be infesting only one small part of the tree as the crawlers are likely to spread after the first application.

Leaf Galls (Unidentified)

The galls are circular and 1/12th of an inch in diameter. Although they are normally found on the leaves they occasionally occur on the tender stems as well. They are caused by an insect, but at the present time there is some doubt as to the species involved. A small wasp, *Achrysocharella* sp., has been bred from them but whether this is the causal agent or merely a parasite of it is not clear.

Life History

This is not known.

Damage

Leaves are usually attacked before they have fully hardened, and as many as 500 galls may be produced on one leaf. Leaf shedding frequently occurs following a heavy infestation, but the extent of this probably depends to some degree upon the vigour of the tree.

Control

No control measures have been adequately assessed. A full-cover spray of 1¼ pints of 60 per cent diazinon emulsion per 100 gallons is suggested for trial.

Thrips (*Selenothrips rubrocinctus*)

Adults are 1/24th of an inch long, dark brown with narrow wings; nymphs are wingless, translucent yellow, with a red band around the middle of the body.

Life History

Eggs are laid in small slits cut in the leaf by the female. All stages occur on the lower leaf surface, where the whole life cycle is completed.

Damage

Adults and nymphs feed by piercing the leaves and sucking the sap. They also excrete small drops of clear reddish fluid over the leaf surface and these harden and turn black. Infested leaves become darkly stained, rusty in appearance where feeding has taken place, curled and shrivelled, and if severely attacked they will fall. The fruit is rarely damaged. Young seedlings are often severely attacked in the nursery but mature trees appear to be comparatively immune to this pest. Hot dry weather favours the build-up of this species.

Control

Although D.D.T. and dieldrin are generally very effective against thrips, their use is liable to precipitate an attack by red spider and scale insects. Therefore a spray of three pints of 50 per cent malathion emulsion in 100 gallons of water directed at the lower leaf surfaces is recommended. A second spray may be required two weeks later if examination shows the presence of newly hatched nymphs.

Mango Seed Weevil (*Cryptorhyncus mangiferae*)

The adult weevil is ⅜th of an inch long and dark in colour. Larvae are white, curled, fleshy and legless.

Life History

Eggs are laid under the skin of young developing fruits after a small cut has been made by the female. The cut heals over and the larva, on hatching, burrows through the pulp and enters the developing seed. The remaining development of the insect takes place in the seed and the adult breaks out after the fruit has ripened. The life cycle takes 40 to 50 days and the pest is confined to mango.

Damage

The slit made during egg laying and the very small tunnel made by the young larva as it burrows through the pulp close up and are normally not seen in a mature fruit, the flavour of which is not impaired. The later larval stages in the seed, however, damage and frequently destroy the developing embryoes, so reducing viability. Certain varieties of mangoes are more susceptible to attack than others, and frequently as many as 90 per cent of the seed of susceptible varieties may be infested.

Control

Orchard hygiene is the only practical measure which it is possible to take. All fallen and rotting fruit and seed should be collected regularly twice a week and destroyed by deep burial or preferably by placing in a drum of water to which a few ounces of old engine oil have been added. When planting in the nursery, first cut open the seed and remove any adults, larvae or pupae, but be careful not to damage the embryoes or allow them to dry out.

Minor Pests of Mangoes

Black Scale (*Saissetia nigra*)

A shiny black scale, hemispherical, $\frac{1}{8}$th of an inch across, which is occasionally found on the fruit.

Scale (*Saissetia exoleta*)

Similar to the above but brown in colour.

Coconut Scale (*Aspidiotus destructor*)

A flattened circular white scale, $\frac{1}{8}$th of an inch in diameter. Solitary individuals are common both on foliage and on the fruit. They cause a distinct yellow chlorosis at the feeding sites. Although easily washed off they leave behind a circular yellow-orange mark which detracts from the appearance of the fruit.

Mealy Bug (*Ferrisia virgata*)

Generally rare but heavy localized build-ups may occur on foliage or fruit. It is a typical mealy bug, about $\frac{1}{8}$th of an inch long with two long filaments arising from the rear end.

Red Spider (Unidentified)

Always present in small numbers, they are normally sufficiently controlled by natural enemies.

Coreid Bug (*Pseudotheraptus wayi*)

A brown sucking bug $\frac{5}{8}$th of an inch long. Adults, and rarely nymphs, pierce and suck the sap of developing fruit. If attacked when young the fruit will fall; if more than $\frac{3}{8}$th of an inch long the fruit normally remains on the tree until maturity but bears small lesions where the skin has been pierced. Damage by this pest is rare in the Malindi area but may be considerable where coconuts and mangoes are grown together in Kwale District.

Fruit Fly (*Pardalaspis cosyra*)

At present this pest can be regarded only as a minor pest of mangoes, although as more mangoes are planted and come into bearing it is likely that it will increase in importance. Eggs are laid in the skin of developing fruit and the legless maggots which hatch out burrow in the flesh; the fruit begins to rot and falls to the ground. The maggots burrow into the soil to pupate. The adults are true flies with one pair of spotted wings, a pale orange body with black markings and somewhat smaller than a housefly. Control consists of (*a*) orchard hygiene as for Mango Seed Weevil, (*b*) the use of poison baits, and (*c*) dusting beneath the trees with 10 per cent D.D.T. dust to kill maggots as they enter the soil. At the time of writing the most suitable poison bait consists of a mixture of 1 fl. oz. 50 per cent malathion, $\frac{1}{4}$ lb. sugar, 1 oz. yeast extract and five pints of water. This should be either hung up on the trees in jars or sprayed as coarse drops on to the foliage (do not cover the whole tree—a patch or two only of each tree should be treated). New poison baits are continually being tested and it is advisable to write to the entomologist to get an up-to-date recommendation.

Stem Miner (Unidentified)

The caterpillar of a small moth mines under the epidermis of tender young shoots leaving patches of dead epidermis which flake off. Believed to be of minor importance.

A MOLASSES GRASS VARIETY TRIAL

By **A. V. Bogdan, Grassland Research Station, Department of Agriculture, Kitale, Kenya**

(*Received for publication on 27th April, 1960*)

Since 1951 numerous samples of molasses grass (*Melinis minutiflora* Beauv.) have been grown in small observational plots at the Grassland Research Station, Kitale. In 1956 12 of the better varieties were selected for further trial in duplicate plots of 1/100 acre each. The trial was planted in April and was continued for three seasons until October, 1958. The seed was sown in 2 ft. rows at 10 lb. per acre and with it was placed one hundredweight of double superphosphate. One hundredweight of sulphate of ammonia was applied in May each year. Some varieties developed faster than others and to avoid punishing the slower types, all were allowed to flower and set seed in the first year, thus making possible a comparison of seed yields. Molasses grass is a late seeder and grazing did not begin till the second season. The plots were grazed seven times: four times in the second year and three times in the third year.

Of the 12 introductions, the following seven were commercial varieties: K52294,* Kitale commercial; K53440 from Uruguay; K53800 from Nyasaland; K53844 from U.S.A.; K53974, a cultivated type from Hoey's Bridge in Kenya; K51144, a cultivated type from Cherangani in Kenya; and K53608 from Nigeria. The remaining five were local wild varieties: K51321 from Rongai; K51149 from Chania River; K53528 from Karatina; K51143 from Lugari; and K53110 from Kapenguria. With the exception of K53608 from Nigeria, six of the commercial varieties showed considerable uniformity in their floral parts, in habit and in performance, and they are practically one and the same type. In four of them the time of flowering was fairly uniform, from 187 to 195 days after planting, while in the other two (from U.S.A. and from Hoey's Bridge) flowering began on the 177th-178th day. The seed yields of these six commercial varieties were much higher than in the others and varied from 147 to 225 lb. per acre; these variations may not be significant as the difference between two plots of the same variety sometimes exceeded the differences between varieties. In the first year all six commercial varieties grew to about 3 ft. in height and produced numerous flowering heads. In the second and third years, when under grazing, they all formed very dense cushions with very numerous small leaves. The plots had an uneven, clumpy appearance and the original rows remained distinct, with a narrow gap between them. However, weed growth in these gaps was very slight. All six commercial varieties were grazed well and their estimated productivity was relatively high.

The remaining six varieties showed considerable variation in nearly all characters and were all distinct types, although the Rongai and Nigerian varieties had much in common.

The Rongai variety had panicles and spikelets similar to those of the commercial types and the time of flowering was about the same as in the earlier forms. It yielded 70 lb. of seed per acre, which was rather poor. Under grazing it produced slightly more robust and vigorous growth and it remained green longer in the dry season. The cushions were less dense, slightly more spreading, with somewhat larger leaves, and although there were no gaps between the rows, these were well marked. This variety was grazed less readily.

The Nigerian variety was distinct from the other commercial or introduced types, and was rather similar to the Rongai variety, although it flowered two weeks earlier—166 days from planting—and was the earliest variety in the trial. The seed yielded was 54 lb. per acre.

The Karatina variety had panicles and spikelets similar to those of the commercial varieties. It flowered early, on the 170th-172nd day, and seed production was higher than in the other indigenous types—96 lb. per acre—though much lower than in the commercial varieties. Under grazing it formed rather loose, prostrate cushions. Throughout the trial it was weak and unproductive with slow recovery after grazing, and with considerable weed infestation. However, towards the end of the trial the ground cover was more even and more complete than in the commercial varieties, and there were no gaps between the rows.

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* Introduction numbers of the Kitale Grassland Research Station.

The Chania River variety had glabrous spikelets with short awns and light purple-coloured panicles, compared with dark purple panicles in the other varieties. The leaves were fairly large, light green in colour, and very viscous. Germination occurred on the sixth day compared with 7-9 days in the other varieties and seedling development was very quick and vigorous. It flowered late, on the 198th day, and yielded only 40 lb. of seed per acre. Under grazing this variety formed an even growth without prominent tufts and was apparently more productive and palatable than the commercial forms.

The Lugari variety had hairless and awnless spikelets. In the first year it developed slowly and formed tall plants with leaves high on the stems. The flowering heads were rather numerous but produced only 11 lb. of seed per acre. Under grazing it formed loose, tall, rather stemmy tufts of a type unusual for molasses grass. The plants remained vigorous for the three years and no weed infestation was observed. The palatability was low although the chemical analysis indicated a relatively high feeding value.

The Kapenguria variety had glabrous spikelets with short awns. It developed slowly from seed, formed tall plants with leaves high on the stem, flowered very late, on the 202nd day, and produced only 14 lb. of seed per acre. Under grazing it formed broad, erect tufts with long harsh leaves placed high on the stem and the herbage was tall and even. Although the sward was vigorous, some weed infestation was observed. The palatability was low.

Although there was a noticeable variation in palatability between the varieties, chemical analyses showed very little difference in their nutritive value. The herbage was analysed when at the grazing stage, and the crude protein varied from 14.5 per cent to 18.2 per cent in the dry matter. The Kapenguria variety, although one of the least palatable, had the highest protein content. The herbage was analysed again in the second year when the plants had reached the grazing stage and had begun flowering. This time the protein content was much lower and varied from 7.6 per cent to 9.2 per cent.

This trial has shown that the commercial varieties are satisfactory, that there is very little difference between them and that there is no need for further comparison of these. Kitale commercial molasses grass was slightly more productive than the others and is therefore recommended as a standard type. Of the indigenous types, the Chania River variety was definitely the best and is the only one which might compete with the commercial forms. It exceeded the commercial varieties in quality and productivity, but as it yielded four to five times less seed, the cost of seed may be high. There are indications that this variety may yield more seed in warmer parts of Kenya, perhaps under irrigation. At the Grassland Research Station there is another promising variety—K5424 from Mbooni Hills, Machakos—a recent introduction which could not be included in the present trial. It has a prostrate, almost creeping, habit and good seeding qualities, but it may lack vigour. These three varieties—Kitale commercial, Chania River and Mbooni Hills—are worth further comparison on a larger scale.

REVIEW

The Conservation of Natural Resources by R. C. Haw, published by Faber and Faber Ltd., London, 256 pp., 36 photographs and 35 diagrams, price 30*s*.

This book, by the instructor in soil and water conservation at the Dombashawa school in Southern Rhodesia, is intended to be simple yet comprehensive. It covers a wide field, ranging from soil erosion and its correction; good land use; organic matter and the soil, tillage; methods of levelling and contouring; dam construction and irrigation; farm planning and the general conservation of natural resources.

In a book of 11 chapters it is inevitable that the author's treatment of his subjects is uneven, and he is at his best when dealing with his own specialities. Thus the chapters on dams, how to level and contour land, and related topics will interest and will be useful to farmers in the tropics unfamiliar with these techniques. The other more practical chapters on tillage, leys and rotations, fodder conservation and veld management will be of more interest to the agricultural novice, being too generalized for most farmers these days.

W.R.B.

THE APPLICATION OF RESEARCH RESULTS TO ANIMAL HEALTH AND DISEASE CONTROL

By Sir Thomas Dalling, Consultant of the Food and Agriculture Organization of the United Nations (F.A.O.), Rome, Italy

The term "research" has a wide meaning and application, and it must not be thought that research work is confined to the laboratory. For many research projects, laboratory work, sometimes on an extensive scale, is essential but, on the other hand, it must not be forgotten that the observations made in the field, the testing out of ideas and the practical application of the results of laboratory work are all included in the term "research". Sometimes research work on problems of animal health and disease actually begins in the field and is extended and brought to fruition by the close collaboration of field and laboratory workers. Field observations are of the greatest importance to veterinarians whose activities are concerned mostly with laboratory work. Because of their clinical training, they themselves may actually make the initial observations leading to the development of ideas, which, in turn, give rise to the initiation of research work on extensive lines.

Fundamental research work is highly valuable and the results may have far-reaching influences on many subjects, including problems which seem far removed from those for which the original work was undertaken, even the control of animal disease.

The results of some of the original research work carried out by veterinarians have been applied to the solutions of problems in other branches of science and veterinary medicine has gained much from research work in general. Many of the present problems on animal disease control will be solved only by research carried out by teams of workers trained and experienced on special subjects: veterinarians have an important place in such teams.

There is a close linkage between human and veterinary medicine and many of the results of research work applicable to the human subject can, with necessary modifications, be applied to animals. Some of the newer methods and techniques used today in improving human health are the results of research work carried out in animals: new developments in human surgery and anaesthesia would not have been possible within so short a time without research work on some types of animals.

In this article there will be given some examples of the application by veterinarians of the results of research work.

Improvement in animal production throughout the world is closely related to breeding the types of animals most suitable for their required purpose, feeding them in such a way that the maximum conversion of the food into the desired animal product will be obtained and improving their health and preventing disease so that animals so bred and fed will be capable of providing the expected results in production.

The use of artificial insemination in the breeding of animals, especially cattle, is one outstanding example of the application and rapid practical development of the results of research work. Techniques in which the artificial vagina is used for obtaining semen from bulls, handling, storage and dilution of semen so obtained and a knowledge of the oestrus cycle from which the optimum time to inseminate was found, have led to the adoption of artificial insemination as a successful method of breeding in many countries. The advantages of artificial insemination are so obvious that they only need passing mention: the use of bulls of desired qualities for producing large numbers of improved offspring; dispensing with the purchase and maintenance of bulls in breeding herds; improvement of low-producing animals in less-developed areas; and the practice of more detailed control of infertility which is now considered to be a part of the artificial insemination service in many countries. The rate of progress in the adoption of artificial insemination must, of necessity, vary in different parts of the world. In countries in which free-range, especially on an extensive scale, is the common method of keeping cattle, it may be possible only to use artificial insemination on a limited scale for, say, the breeding of special males for use in the future. On the other hand, in milk-producing herds and even in beef-producing animals kept under more controlled conditions, there has been a very rapid expansion of this method of breeding: for example, in Denmark it is stated that nearly 100 per cent of cattle are so bred, in Holland some 65-70 per cent, in England 50-60 per cent, and in the United States the figure for milking cows is given as 31 per cent which is included in the total of nearly 8 million cows inseminated annually. The more recent discovery that semen can be successfully stored at low temperature for several years is an advance of such magnitude that the future possibilities of breeding satisfactory cattle in almost any part of the world is assured. Careful consideration has, of course, to be given to the selection of the most appropriate bulls, as far as possible including progeny-testing, as well as to the application of the most severe tests to ensure the freedom of the bulls and the semen from any agent likely to cause transmissible diseases in the inseminated females. Veterinary supervision of the health of the bulls is absolutely essential, and although not carried out in all countries today, veterinary supervision of all the aspects of artificial insemination is a legal condition of its practice in some other countries. It is common now to include sexual hygiene and the control of infertility in artificial insemination services in some countries, the necessary examinations and treatments being carried out by veterinarians.

Research work on animal nutrition is receiving much attention throughout the world. Much of this work has to be done by individuals and teams of workers specially trained in the many aspects of the subject. Veterinarians are intimately concerned with the effects which introductions of new feeding systems and feeding stuffs may have on the health of animals. It sometimes happens, for example, that the earliest evidence that a pasture is deficient in some essential element or that a system of feeding is at fault is reflected in the clinical health of animals. Much of the research work on deficiencies and excesses of trace or minor elements arose from field observations and the results of much of the research work in remedying these conditions was left to the observations of veterinarians in the respective areas. Veterinarians are greatly assisted by research workers in the many problems appertaining to nutrition. A veterinary research laboratory today would be very incomplete without a team of biochemists, some of whom are veterinarians, whose special work concerns research into the causes of ill health in animals related to nutrition. Hypomagnesaemia or "grass tetany" is an example of a condition which, in some seasons, causes much concern, especially to dairy farmers. The disease is associated with a fall in the blood magnesium levels, the actual cause of which has not yet been determined. It occurs on pastures which have a relatively high magnesium content and thus, although the recognized amounts of magnesium may be present, there apparently exists some mechanism whereby they are not available or are not in a satisfactory state to meet the requirements of the animal tissues. Research work has shown that the daily consumption of two ounces of calcined magnesium will probably prevent the occurrence of the condition, if fed for a period before animals are given access to a pasture in which hypomagnesaemia is likely to occur. The daily feeding of this medicament is stressed, for it has been found that a single large dose given soon before turning the animals on to the pasture does not prevent the disease. It has also been shown that top-dressing of pastures with magnesium compounds is beneficial: the condition under which the compounds should be applied and the amounts to be used vary with circumstances and advice on the subject should be obtained. Copper deficiency in lambs causes the disease known as "enzootic ataxia" in Australia and as "swayback" in Great Britain: the condition is characterized by lesions in the brain of affected lambs, consisting of cavities, often present at birth, which should contain white matter. The feeding of copper sulphate to the pregnant ewes prevents the disease. A deficiency of the amount of cobalt in the pasture, necessary for the formation of vitamin B12 in the rumen of sheep, occurs in some parts of the world. The intensity of infestation with worms in the alimentary tract is sometimes related to this deficiency. The addition of as small an amount as 0.1 parts per million of cobalt in the diet provides all the requirements. Excess of molybdenum in feeds or in pastures, especially on soil composed of peat where there is a deficiency of copper, may cause poisoning in cattle, sheep and goats. The feeding of small amounts of copper sulphate as well as the application of fertilizers containing small amounts of copper to the grazing land prevents the condition. Vitamin deficiencies may give rise to diseases in animals. In nutrition of poultry they may be marked and cause serious trouble, Vitamin A deficiency, for example, interferes with normal growth and egg production with the occurrence of recognizable symptoms and lesions, while deficiency of vitamin D interferes with the normal metabolism of calcium and phosphorus leading to abnormal bone development or rickets in young growing birds even although the diet contains adequate amounts of these elements. These are but a few examples of the results of research work on the nutrition of animals, the application of which is improving animal health and animal production.

Research work is resulting in many improvements in our knowledge of the causes, distribution, prevention and treatment of diseases of animals. The list is long: only a few examples can be given but they will serve as illustrations of veterinary activities in this direction. Serological tests are in daily use for diagnosing some of the important animal diseases: the nature of the test varies with the type of infection. They show the presence of substances in the blood, produced by tissues of the infected animal in efforts to deal with the invading agent. One of the simplest of the serological tests demonstrates agglutinating anti-bodies in the serum of infected animals. The test is widely applied, for example, in the detection of "carriers" of pullorum disease among breeding fowls and in the diagnosis of *Br. abortus* infection in cattle.

Research work has resulted in the application of the test by rapid methods actually on poultry farms when only a drop of whole blood, instead of blood serum, from individual fowls, is used by the "rapid" or "slide" method and "carrier" birds, diagnosed on the spot, can be disposed of at once. While sero-agglutination tests have been and are widely used in diagnosing brucellosis, research work has led to the now well-known ring or ABR test on samples of milk in which a blue-stained emulsion of *Br. abortus* is added to the milk. A positive reaction is shown by the appearance of a blue ring, consisting of the cream to which the agglutinated coloured organisms are adhering, which rises to the top of the sample. This test is valuable for screening infected herds, the finding of a positive reaction in mixed samples of milk from a number of animals being followed later by the application of the sero-agglutination test to samples of serum from individual animals to detect those actually infected. There is now in existence an international standard anti-*Br. abortus* serum against which national standards can be tested for use as control sera in agglutination tests. Recommendations on the techniques of carrying out the tests and the interpretation of the results have been made in order that there may be uniformity in the results reported in different countries: this seems necessary in connexion with the export and import of live cattle.

Sero-agglutination tests are also used in determining the actual type of salmonella and leptospira infecting animals. In the test for such purposes, cultures of the organisms recovered from the infected animals are used and stocks of the sera, known to cause agglutination of the different types, are prepared and kept in readiness for use in the tests.

Sometimes for the diagnosis of some diseases it is necessary to carry out more elaborate serological tests than the simple agglutination test: for example, the complement-fixation test used in the diagnosis of dourine in horses and the conglutination test in the diagnosis of Johne's disease. An interesting and important extension of the use of the agglutination test for the diagnosis of trichomonias and genital vibriosis in cattle followed an understanding of the stage of the oestrus cycle when agglutinating substances are present in the vaginal mucus, which is used in the test instead of blood serum.

The diagnosis of bovine tuberculosis in cattle has been much improved by the results of research work by biochemists, in the production of tuberculins in a higher state of purity than those formerly used. Investigations into the nature and extent of reactions following the intradermal injection of appropriate amounts of purified tuberculins, prepared from mammalian and avian cultures of the tubercle bacillus, are assisting in the differentiation between sensitivity to tuberculin due to bovine tuberculosis and that arising from other types of tubercle bacilli and other micro-organisms. In the research work, veterinarians have played an outstanding part.

Notable advances in the control of some diseases of animals have followed the application of research results to the production of vaccines from viruses passed through animals of less susceptibility than that of animals commonly infected, and the conservation of such "attenuated" vaccines in a freeze-dried condition. There are several examples, two of which are now referred to.

One concerns the control of rinderpest (cattle plague). In earlier days, protection against the disease was accomplished by the use of serum from cattle which had recovered from the infection, the injection of which was followed by protection for a comparatively short period; or by injecting infected blood and controlling the resulting infection by the simultaneous injection of protective serum, which resulted in immunity of long duration. Vaccines composed of inactivated tissue from artificially infected cattle became available. While, on the whole, these methods gave good results, difficulties and inconveniences were experienced in their use. Research into the effects of passing the virus through animals other than cattle resulted in the production of virus in an attenuated state so that its injection did not set up the disease in cattle but was followed by high and lasting immunity. The goat was and still is used for this purpose and goat-attenuated virus is the most common vaccine now available. It was found, however, that passage through the goat did not render the virus sufficiently attenuated to prevent undesirable reactions in highly susceptible cattle and buffaloes in some countries. Rabbits and, later, developing chick embryos in fertile hen eggs, or a combination, were used for purposes of attenuation. The result of all this research work is that there are now available vaccines in states of attenuation likely to be satisfactory for immunizing animals in almost any part of the world. The application of freeze-drying has resulted in the conservation of the virus in this form over long periods, its availability on demand and its easy transport in serviceable condition.

The production of vaccine for the control of Newcastle (Ranikhet) disease in poultry is the other example. The cultivation of the causal virus in the developing chick embryo is usually sufficient for its attenuation to a degree suitable for use for immunizing fowls. This virus-vaccine is also preserved and issued largely in a freeze-dried state. For very young chicks, the susceptibility of which may often be greater than that of adult fowls, a virus of natural low virulence is used in the preparation of vaccine.

The cultivation of cells of body tissues apart from the living body has been steadily developed over a considerable number of years and such cultures are now being used to grow disease-producing viruses. This method has been recently used for the cultivation of the virus of foot-and-mouth disease in preparation of vaccine for the prevention of the disease in cattle. In preparing foot-and-mouth disease vaccine plentiful supplies of suitable virus are required. For many years this virus was produced by infecting the tongues of susceptible cattle and harvesting the tongue membranes: in fact, this method is still very extensively used. It was found, however, that if the cells in the deep layer of the covering membrane of the tongue were removed from the newly slaughtered animal and placed in suitable nutrient material, there was still sufficient "life" in them to enable the virus of foot-and-mouth disease to grow in them: and so, a new successful method of cultivating the virus was introduced. The latest method is to use growing cultures of cells, kidney cell cultures being found suitable. Thus, by the application of results of research work, large amounts of the virus, found suitable for vaccine preparation, are now produced by methods which exclude the use of the living animal.

Some disease-producing micro-organisms form toxins which are the actual causes of the diseases. In animals, this is the position with many of the anaerobic bacteria, e.g. those causing tetanus (lockjaw) and especially some diseases of sheep. At one time it was thought that each of the different anaerobes produced one toxin only. Careful research work, however, showed that, given the necessary conditions, different toxins can be produced by the same organism. This was a big step forward in understanding the nature of some of the anaerobic infections of sheep and cleared up some of the reasons for failure in attempts to immunize animals against them. An outstanding example is the anaerobic organism which causes gas gangrene in man following the infection of wounds and which was responsible for so many casualties and deaths in the First World War. An apparently similar organism was shown to be associated with different diseases of lambs and adult sheep, viz. enterotoxaemias, in which its multiplication and toxin production takes place in the intestine. Research work showed that the organism which responded to many of the tests for that causing human gas gangrene had the power of producing a variety of toxins and that these different toxins were largely responsible for the different diseases of lambs and adult sheep. By further research work, much of which was carried out in veterinary laboratories, there were evolved vaccines which protected against either one or a mixture of the toxins: such vaccines are now in general use in controlling some of the diseases of sheep in some countries and are giving satisfactory results.

An interesting discovery was made in studying methods for protecting very young lambs against the disease, lamb dysentery, in which the infection takes place and the disease becomes established during the first few days after birth. It was shown that lambs born from mothers which had been vaccinated and had developed protective substances were protected against lamb dysentery. One of the methods introduced to protect the young lambs against this disease was, therefore, to use vaccine on the pregnant sheep. The results were highly satisfactory. It had been quite generally believed that the protective substances developed in the mother passed to the lamb before birth. Research work showed, however, that transference of the protective substances did not take place before the lamb's birth but that they collected, in high concentration, in the ewe's udder and were thus readily available for the newly born lamb in the colostrum. It was also shown that these protective substances were absorbed from the intestine into the lamb's general blood circulation during the first few days after birth and that, thereafter, little absorption took place; and further, that as milk replaced the colostrum the amount of available protective substances gradually became less and less and they finally disappeared.

Much research work has been done on the preparation of vaccines for the production of immunity. Such vaccines must be safe to use and, at the same time, be capable of inducing a high degree of immunity. With some organisms, it was found that heating to a certain temperature for a definite period produced the required result. With some others, and with toxine, research work showed that treatment with a chemical agent was satisfactory and this led to the introduction of formolized toxins or "anatoxins" as immunizing agents, followed later by formolized cultures or "anacultures". Examples in vaccines used in animals are those for producing immunity against some of the diseases caused by toxins formed by anearobic organisms. Although formalin is largely used for inactivation purposes, research work is continuing with other chemical substances which, it is hoped, may give even better results. Research also showed that by adsorbing anatoxin or anaculture to a chemical substance, the injected material was slowly released from the site of injection and that this caused steady production of protective substances by the responsible mechanism in the body. Hence, a number of vaccines in use today, including those used for protection against some virus diseases, consist of the inactivated adsorbed toxin, bacteria or virus. Some virus-vaccines, as already mentioned, consist of the virus in a living but attenuated state, the attenuation having taken place naturally or by artificial means, e.g. passage through another species of animal.

The many aspects of research work are, of course, being continued all the time. New medicaments, including antibiotics, are being fully tested and used to full advantage when found suitable and satisfactory in the control of animal diseases, e.g. in mastitis in cattle associated with certain micro-organisms. Antibiotics and other new drugs together with new operative techniques have made possible surgical work, often major in character, in all speices of animals—operations which, at one time, were thought impossible to carry out.

Following upon research studies, much progress has also been made in our knowledge of reproductive disorders in animals and their control.

This progress concerns not only infectious diseases, transmitted venereally, but has been made from the results of study of the genital systems and the influence of the many substances secreted by glands and other tissues, on the reproductive organs and their functions. It is now possible to restore many animals with impaired fertility, at one time believed to be permanently sterile, to normal breeding capacity. Much of the present-day information on the subject relates to cattle. Infertility in sheep is also receiving attention. An example is the research work in New Zealand which has shown that the widespread infertility in rams is caused by infection of the genital organs with an organism of the brucella group, peculiar to sheep. The infection is mostly transmitted from rams to ewes at mating and, in turn, infected ewes transmit the disease to healthy rams. In addition to impaired fertility in rams, the infection is responsible for abortion in ewes and deaths in lambs at about the time of their birth. Recent work shows that this disease in rams can be prevented by the use of suitable vaccines before the breeding season.

Studies of the life cycles of parasites is leading to a better appreciation of the stages of development at which it is most convenient to apply measures to prevent further development, taking into account control of any intermediate hosts and the most appropriate time to use drugs to destroy the parasites within the host. The recent work on the immunization of calves against lung-worm infection by the injection of the worm larvae partly inactivated by "X" irradiation opens up a new and important field in the control of some internal parasites.

These few examples illustrate the part played by research work in the development of measures for the control of animal diseases. They also show the part which veterinarians are taking not only in the application of the results of research work but also in the studies themselves.

RELEASE OF NEW CEREAL VARIETIES–1960

By H. C. Thorpe and G. E. Dixon, Plant Breeding Station, Njoro, Kenya

(*Received for publication on 26th April, 1960*)

The following new wheats are released by the Department of Agriculture for the 1960/61 season. All four varieties were bred in other countries and no new names are being given to them; all are direct multiplications from the International Spring Wheat Rust Nurseries of 1954 or 1955.

AFRICA MAYO

A variety bred in Mexico, from the cross Africa × Mayo 48, under the selection number 3529-ly-4m-3y-1m.

This is a bearded, white-chaffed, red-grained variety of quick maturity, fair straw strength and good baking quality. It has shown good resistance to stem rust except in one instance and has proved high yielding. It has some susceptibility to yellow rust, but is resistant to brown leaf rust.

Africa Mayo is recommended for areas from 6,000-7,000 ft.

KENTANA YAQUI (2587)

A further variety bred in Mexico, from the cross Kentana × Yaqui, under the selection number 2587-8y-6c-1y-3c.

This is a beardless, red-chaffed, red-grained variety, of quick maturity, good straw strength and good baking quality. It has shown good resistance to stem rust and fair resistance to brown leaf rust. It is rather susceptible to yellow rust, and specially susceptible to glume blotch.

Kentana Yaqui is recommended only for areas from 6,000-6,500 ft.

WISCONSIN SUPREMO

A variety bred in Mexico from the cross Wisconsin 245 × Supremo, under the selection number 3638-5h-1h-2h. The Wisconsin parent derives from the interspecific cross (Illinois 1 × Chinese)^3 × *Triticum timopheevi.*

This is a bearded, white-chaffed, red-grained variety, of quick maturity, poor straw strength and good baking quality. It has shown exceptionally good resistance to stem rust and brown leaf rust, but some susceptibility to yellow rust.

Wisconsin Supremo is recommended for areas from 6,000-7,000 ft. with a possible extension to 7,500 ft.

MIDA MCMURACHY EXCHANGE

A variety bred at Minnesota from the cross Mida-McMurachy-Exchange under the selection number II-47-26.

This is a bearded, red-chaffed, red-grained variety, of slow maturity, fair straw strength and fair baking quality. It has shown exceptionally good resistance to stem rust and good resistance to brown leaf rust and yellow rust.

Mida McMurachy Exchange is recommended for areas from 7,000-8,500 ft.

Below is appended a summary showing the names of the varieties together with their main characteristics:—

NAME	Ear Type and Chaff Colour	Grain Colour	Maturity	Baking Quality	Altitude Range
Africa Mayo	B'ded, white	Red	Early	Good	6–7,000
Kentana Yaqui	B'less, red	Red	Early	Good	6–6,500
Wisconsin Supremo	B'ded, white	Red	Early	Good	6–7,500
Mida McMurachy Exchange	B'ded, red	Red	Late	Fair	7–8,500

Stem rust: *Puccinia graminis tritici.*

Brown leaf rust: *Puccinia recondita* (P. rubigo-vera).

Yellow rust: *Puccinia glumarum.*

Glume blotch: *Septoria nodorum.*

THE ESTIMATION OF ANKOLE AND ZEBU CATTLE WEIGHTS BY GIRTH MEASUREMENT

By **D. D. Thornton, Department of Veterinary Services and Animal Industry, Uganda**

(Received for publication on 2nd May, 1960)

The growth and development of an animal reflects the climatic and imposed management factors of its environment. Regular knowledge of individual animal weights is indispensable to optimum progress in livestock rearing and production however good the stockman's visual appraisal of the well-being of his herds. In African areas weighing facilities are found only on Government farms and a few large commercial holdings.

Apart from the need for some simple means of estimating cattle weights on the increasing number of progressive farms in Uganda this knowledge is also often required in veterinary medicine. In parts of Western Province, Uganda, cattle are maintained in contact with tsetse fly when the attendant disease of trypanosomiasis is important or on pastures infected with liverfluke. Safe and effective prophylactic and curative drug dosage levels are calculated from body weights. Inaccurate treatment may lead either to serious problems in resistance of the disease producing organisms, or to death from excessive dosage.

The need for a rapid field estimation of animal weight is apparent and the present article investigates a possible method using the Dalton cattle and pig weighing tape.

Ross (1958A) has briefly reviewed the literature on the correlation of linear body measurements to weight. The heart girth has proved to be the most satisfactory single measurement in body weight estimations. Ross used a modification of the "Minnesota formula" (Johnson, 1940), $W = G^2 \times L \div 213$, where G = heart girth in inches, L = body length in inches and W = weight in pounds. Eighty per cent of the 108 animals used to obtain the correction constant gave estimated weights within 10 per cent of weighbridge body weight. Ross (1958B) compared the use of a heart girth scale with the above formulation on 214 White Fulani cattle in Nigeria and obtained equally accurate results. Two-thirds of the sample were estimated to weigh within 8 per cent of the actual scale weight.

The previous work consulted does not discuss the validity of a single weighbridge reading as a basis for comparison with estimated weights. Individual readings for kraaled cattle may vary over 10 per cent of body weight during the course of a grazing day (Wilson, 1960). Only Ross (1958A) amongst Uganda workers mentions time of weighing, between 7 and 8 a.m.

MATERIALS AND METHODS

The heart girth and corresponding weighband and weighbridge weights of 337 Ankole Longhorn and Shorthorn Zebu cattle varying in age from ten months to ten years were recorded on the Veterinary Department stock farm, Mbarara, Uganda. The readings were obtained in February, 1958, in the course of a routine monthly weighing when animals approached the weighbridge along a convenient crush corridor. The herds are not penned at night and the single weighbridge reading was regarded as a normal weight taken between 8 a.m. and 11 a.m. The Dalton weighband is graduated in cm. and carries four weight scales in lb. so that a direct reading is obtained. The scale for normally fed cattle was used in this investigation, the measurement being taken immediately behind the forelegs pulling the band comfortably tight but not holding it under strain. The tape passes behind the apex of the hump in Zebu cattle.

RESULTS

Comparative weighbridge and weighband live-weight figures were obtained for 98 female and 70 male Zebu and 107 female and 62 male Ankole stock. Of the 121 animals showing a smaller weighband reading 30, or 25 per cent, were Zebu, as were 138 out of the 215, or 65 per cent, of the heavier than weighbridge estimates. These figures indicate that the Dalton Weighband tends to give high body weights for the Teso Zebu while the distribution of the Ankole readings around the weighbridge weight approaches normality. The slight tendency of the Ankole to give a lighter than scale weight may be due to the poor hindquarter development and "leginess".

The standard deviation for the difference between tape estimation and weighbridge weight for the whole sample was 34 lb. (mean 35 lb.) or expressed as the percentage difference of the weighband over the weighbridge weight, the standard deviation is 6.3 (mean 8.0). Small differences in the standard deviation appear when the sample is grouped according to breeds and sex (Table I).

TABLE I—THE STANDARD DEVIATION OF THE PERCENTAGE DIFFERENCE BETWEEN THE WEIGHBAND AND WEIGHBRIDGE READINGS FOR BREED AND SEX

Breed	Sex	Number	S.D.	Mean
Ankole ..	M.	62	5·6	7·1
	F.	107	5·5	7·8
Zebu ..	M.	69	6·1	8·3
	F.	99	6·6	8·5

The data may be further tabulated in arbitrary weight groups suggested by Ross (1956A). From Table II it is seen that the accuracy of the weighband method increases up to the 601-800 lb. range and then declines. Seventy-nine per cent of all animals in this weight group are estimated to within 10 per cent of the single weighbridge reading. If separate breeds are considered the Ankole animal is more accurately weight-estimated in the 401-600 lb. weight group. Three-quarters of the Ankole breed fall within 10 per cent of the actual live-weight (single weighing) whereas only two-thirds of the Zebu stock come within this limit of accuracy. It is suggested that the Zebu hump might account for the high number of overestimates resulting from an enhanced chest circumference.

TABLE II—FREQUENCY OF PERCENTAGE DIFFERENCES IN WEIGHBRIDGE OVER WEIGHBAND WEIGHTS BY 200 LB. WEIGHT GROUPS

WEIGHT GROUP IN LB.	UNDER 2·0%		2·1–5·0%		5·1–10·0%		OVER 10%	
	A	Z	A	Z	A	Z	A	Z
0–200 ..	2	2	4	5	7	8	9	4
201–400 ..	6	9	15	10	10	25	10	35
401–600 ..	7	14	14	9	15	10	6	14
601–800 ..	3	3	12	5	19	6	12	1
801–1000 ..	—	—	4	1	7	2	6	2
1001–1200 ..	—	—	—	—	1	1	—	2
% of sample	11	17	29	19	35	30	25	34

The exact age of 233 of the animals used was known and as would be inferred from Table II, the weighband exhibits increasing reliability with advancing age up to five years although the improvement in the standard deviation of the percentatge difference between weighbridge and tape weights is small.

CONCLUSIONS

By whatever method it is assessed live-weight remains a partially subjective determination. This is not a handicap in its use provided the time and technique of weighing are standardized so that consecutive weighings of the same individual are comparable. The data indicates that a set of weighband readings for Ankole cattle would be a valuable guide for the stock owner or veterinarian. It is suggested that estimated live-weight figures for the Zebus examined with the Dalton tape do not reach a reasonable level of accuracy. The indigenous cattle of Ankole District, Uganda, number some 250,000 and the need for veterinary treatment requiring the patient's weight is sufficiently large to warrant the use of a simple linear measurement for weight recording.

SUMMARY

The use of the Dalton Cattle and Pig Weighband on Ankole Longhorn and Shorthorn Zebu is investigated. The standard deviation of the percentage difference between weighband and single weighbridge readings was 6.3 (mean 8.0). Sixty-five per cent of the Zebus and 75 per cent of the Ankoles were weight-estimated to within 10 per cent of actual weight. The heart girth scale is proposed for veterinary purposes.

ACKNOWLEDGEMENTS

The writer wishes to thank Mr. G. D. Sacker, officer-in-charge, Veterinary Department stock farm, Mbarara, for allowing the cattle to be used for the investigation, and Mr. P. Butyokoza for recording the weights of the animals. The permission of the Director of Veterinary Services and Animal Industry, Uganda, to publish this article is gratefully acknowledged.

The weighband was obtained from Dalton Supplies Ltd., Nettlebed, Henley-on-Thames, Oxon, England.

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ARMILLARIA MELLEA IN KENYA FORESTS

By I. A. S. Gibson, Forest Department, Nairobi, Kenya, and N. A. Goodchild, Tea Research Institute, Kericho, Kenya

(Received for publication on 30th May, 1960)

A brief reference has already been made to a survey of the incidence of *Armillaria mellea* (Vahl.) Quel. in Kenya forests (Gibson, 1960). Since this publication more information has been obtained which is reported and discussed below.

Conifer and Hardwood Forests

Previous workers on Armillaria Root Disease in East and Central Africa (Butler, 1928; Wallace, 1935, Leach, 1939) have noted that the characteristic rhizomorphs of *A. mellea* are rare or poorly formed under natural conditions. This contrasts with observations made in the Kenya Highlands during the last few years, where it has been found that rhizomorphs occur relatively frequently.

The present survey was based on these characteristic structures, which were used to identify the fungus in association with tree roots. The sampling of a forest area was based on units of about 30 trees each espaced along a line at intervals between 100 and 200 yards. Each tree was examined for rhizomorphs on its lateral roots by removing the soil to a radius of one yard around the bole; the vernacular name of the tree was noted and if rhizomorphs were present these were sampled and the presence or otherwise of associated mycelium under the root bark or rot, was recorded. The samples were later checked by independent examination. No tree of diameter less than 4 in. butt diameter was included.

Thirteen forest areas have now been examined, of which 12 were in the Conservancy East of the Rift, and the results have been summarized in Table I.

All common tree species sampled were found to carry epiphytic rhizomorphs of *A. mellea* and no reliable variation has been made out between the degree of infestation occurring between one species and another. The only species on which rhizomorphs have not been recorded occurred in the survey so infrequently that this observation had little significance. As might be expected, the number of trees associated with *A. mellea* varied widely between samples from the same forest area. No statistical analysis has been attempted with the present figures and it is felt that a survey with this in view would have to be very much more exhaustive.

Table I—Summary of a Forest Survey for *Armillaria mellea* in Association with Indigenous Forest Trees

Forest Station	Altitude ('a.s.l.) —	Average Rainfall (" p.a.)	Number of Trees Found with *A. mellea*			Total Examined	% Associations
			(*a*)	(*b*)	(*c*)		
Timbilil (Kericho)	7,000	75	406*	—	—	1,330	30·5
Chehe (S. Mt. Kenya)	6,800	60	55	5	54	299	38·1
Kiandongoro (E. Aberdares) ..	7,800	59	205	12	12	458	50·0
Kieni (S. Aberdares)	8,000	56	78	9	26	240	47·1
Uplands (S. Aberdares)	7,900	54	111	0	8	288	41·3
Ragati (S. Mt. Kenya)	6,600	52	33	5	46	432	19·7
Kerita (S. Aberdares)	8,000	52	75	5	7	226	38·5
Hombe (S. Mt. Kenya)	7,000	50	25	1	21	178	26·4
Rugongo (Aberdares, Nakuru) ..	7,600	48	19*	—	—	127	14·9
South Kinangop (S.W. Aberdares)	8,400	47	49	2	2	243	21·8
Dundori (Aberdares, Nakuru) ..	7,000	45	35	6	26	315	21·2
Kabaru (S.W. Mt. Kenya) ..	7,400	43	28	4	9	230	17·8
Muguga (Kikuyu)	6,800	35	6	0	0	300	2·0

*Surveys results at these stations were not differentiated into types of associations.

(*a*) Trees bearing epiphytic rhizomorphs.

(*b*) Trees with epiphytic rhizomorphs and limited mycelial invasion of root.

(*c*) Trees with rhizomorphs associated with white rot of root.

The figures presented show a marked decline with annual rainfall with two outstanding exceptions at Ragati and Timbilil, where the number of records is considerably below expectation. This decline in rhizomorph frequency is not directly related to that of the fungus or its activity as a pathogen. For instance, at Muguga where very few rhizomorphs were found, Armillaria Root Disease still causes loss in pine plantations.

The frequency with which rhizomorphs were associated with incipient root invasion or rot was extremely variable and bore no relation to any other factor of the environment. It would appear that, given favourable conditions for their formation, rhizomorphs can spread considerable distances from a food base.

A general correlation between severity of attack of Armillaria Root Disease and the natural abundance of rhizomorphs has already been noted (Gibson, 1960), but the wide difference between the number of potential centres of infections in the natural forest and those actually realized in subsequent plantations, is worthy of further study.

Bamboo Forest Areas

A successful search for rhizomorphs of *A. mellea* associated with bamboo (*Arundinaria alpina* K. Schum.) was made after Armillaria Root Disease was recorded in pine plantations established in areas of cleared bamboo forest. This was followed by surveys to determine whether these associations were derived from the stumps of the occasional trees growing in the bamboo forest area after clearing, or whether the associations were independent of this.

At Gatare, a series of samples were taken of bamboo residues in the soil to a radius of one yard around 24 stumps found to be infested with rhizomorphs and 59 stumps apparently free from this association. Of 167 residues in the vicinity of infested stumps 116 had rhizomorphs while 234 residues from uninfested stumps had only seven rhizomorph associations. This strongly suggested that bamboo associations were derived from infestations of trees after felling. However, at Kiandongoro a further survey showed a somewhat different relationship. Here, in bamboo forest that had been cleared for only three months, little difference was found in the proportion of infested bamboo residues in the vicinity of tree stumps and samples taken 30 to 40 yards away from them. Similarly, in areas cleared for 12 months the proportion of infested residues was very similar to that in neighbouring areas cleared for only three months.

Thus it would appear that, at least in certain areas, bamboo forms probably natural associations with *A. mellea* which may in turn transmit disease to subsequent forest crops if they are sufficiently susceptible.

Acknowledgements

We would like to acknowledge the assistance of Ranger Stephen W. Kingori, who was in charge of the field operation of the greater part of this survey, and Samual Kipkirui arap Birir, who was responsible for most of the fieldwork at Timbilil.

Summary

A survey of Kenya Highlands forests had shown that a very high proportion of indigenous trees have root associations with the rhizomorphs of *Armillaria mellea*. The frequency of these associations in any area generally appears to be proportional to rainfall. Bamboo (*Arundinaria alpina*) has also been found to carry epiphytic rhizomorphs of *A. mellea*.

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REVIEWS

A Report on Cacao Research, 1957-1958, at the Imperial College of Tropical Agriculture, Trinidad, West Indies. Copies of the report available from Trinidad or the London office, 40 Norfolk Street, W.C.2, published 1959, 86 pp., price 15*s*.

The report contains a paper on Incompatability in Theobroma cacao by F. W. Cope. This paper represents the results of ten years study of the mechanism in the ovule of the cocoa flower. A short note on the propagation of cocoa in plastic bags, by R. Nichols, is most interesting. There are three papers by G. K. Maliphant; one on the nutrition of cocoa, one on size yield correlation, and one on manurial and cultural experiments on cocoa. In all, the report covers 19 papers by the college staff who are engaged on cocoa research.

To anyone interested in cocoa, this report will prove most valuable. The propagation of cocoa in plastic bags might well be a useful technique for growers in East Africa. The cocoa research section of the Regional Research Centre is not confined to Caribbean problems, but is world wide in its range.

W.B.M.

Rations for Livestock by R. E. Evans, published by Her Majesty's Stationery Office, London, as Bulletin No. 48 from the Ministry of Agriculture, Fisheries and Food, 1960, pp. 134, price 7*s*.

This classic bulletin on the rationing of livestock has been reissued under the supervision of Dr. R. E. Evans who has rewritten much of the descriptive material. A number of major changes have been made in the present edition, thus brief descriptions of the more common feedingstuffs used in England have replaced the section on self-sufficiency on the farm; the section on rationing horses has been deleted (a commentary on changing husbandry) and separate tables of composition and digestibility are now given for ruminants and pigs.

Although it needs no new recommendation it is again worth stressing that it is an excellent reference book for all who work with livestock. The farmer will perceive in it a sound commentary on the progress of scientific feeding as well as a guide to the economical use of his fodders while the needs of agricultural colleges and advisory services are not forgotten.

J.G.

Industrial Fibres (No. 10), 1960, 236 pp. Price 10*s*. net. Obtainable from H.M. .Stationery Office, or from the Secretary, Commonwealth Ecomonic Committee, 2 Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

Industrial Fibres presents in convenient form reviews of production, international trade, consumption, stocks, prices and customs duties for the following commodities: wool, coton, rayon and other man-made fibres, mohair and other fine hair, silk, flax, jute and jute manufactures, sisal and other hemps, coir and kapok. The present volume covers in detail, developments up to the close of the 1958-59 season, while at the same time comparisons are given for earlier post-war seasons as well as for the average of the immediate pre-war years. In each section particular reference is made to the part played by the Commonwealth countries and to their interests, whether as producers or consumers. A special section describes changes in the position of the six Common Market countries of Western Europe as markets for Commonwealth fibres.

The present edition contains not only all the regular features of earlier editions brought up to date, but also much new material.

Water Deficiencies in European Agriculture, by J. C. J. Mohrmann and J. Kessler, published by the International Institute for Land Reclamation and Improvement, Wageningen, Netherlands, 1959, 60 pp., two diagrams, ten maps. Price $1.75.

This is the fifth in the series of studies of water and soil in Europe. It is mainly concerned with the extent to which precipitation is capable of supplying crops with water. The general conclusion is that much of Europe needs supplementary water for better crop growth although this may be uneconomic at present.

The book should be of interest to everyone connected with studies of rainfall use by vegetation.

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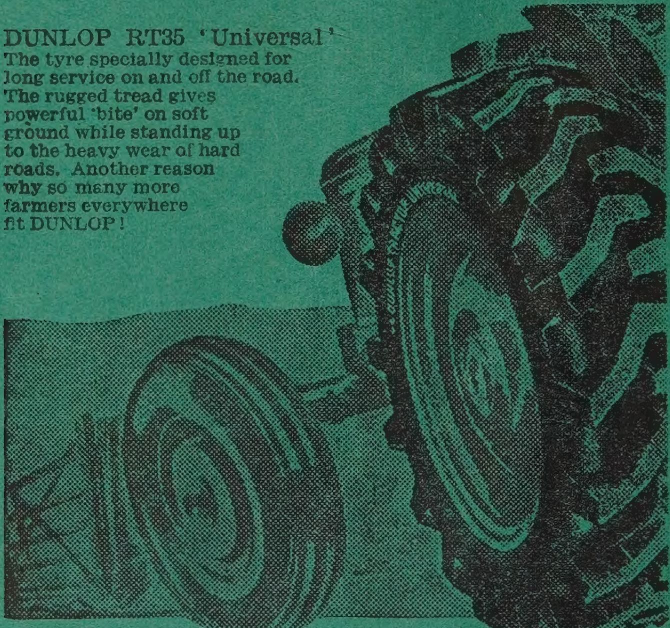

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